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TIBIA VARA

Osteochondrosis Deformans Tibiae

BY W. P. BLOUNT, M.D., MILWAUKEE, WISCONSIN

From The Marquette University Medical School, the Children's Hospital, and the Columbia Hospital, Milwaukee

During the past twenty years the medical journals have been deluged with articles on "osteochondritis" at this or that epiphysis. Mention has frequently been made of involvement of the proximal end of the femur, of the tonguelike projection of the proximal tibial epiphysis, of the tubercle of the calcaneum, and of the secondary epiphyses of the vertebrae. Abnormal development of almost every epiphysis in the body has been recorded and will be found if a careful search is made. Buchman has mentioned a number of examples. To his list might be added Thiemann's disease of the phalanges[48], Madelung's deformity of the distal end of the radius[35], and an osteochondral lesion of the ischiopubic hiatus[2].

Erlacher reported a case in 1922 in which there was involvement of the medial half of the left proximal tibial epiphysis. In the same year McCurdy reproduced the roentgenograms of a typical bilateral tibia vara and labeled the condition Perthes' disease, but did not mention the case further. In 1929 Lewin described a similar case of Ritter's (Fig. 1). A few more isolated examples had been reported when in 1930 Lülsdorf collected five from the literature and added three of his own. The writer has found six others before that time and nine since then, which are reported with thirteen new ones.

The condition has been variously designated as rickets, chondrodysplasia, a growth disturbance, an unusual epiphyseal change, an epiphyseal defect, osteitis of the upper end of the tibia, and as an unknown disease. Lülsdorf called it "epiphysitis tibiae deformans". It is not an inflammation, however, and, in accordance with the more recent usage, the name should not contain the suffix "itis". It is not limited to the epiphysis, but is an abnormality of growth of the metaphysis, epiphyseal cartilage, and osseous center of the epiphysis. The name should imply

TABLE I

SUMMARY OF UNPUBLISHED CASES

Case No.	Initials	Sex	Age		Side	Type *	Deformity	Roentgenographic Findings	Treatment	Age at Operation (*Years*)	Recurrence	Remarks
			At Onset (*Years*)	When Seen (*Years*)								
1	J. H.	Female	1	3½	Both	I	Varus { Right, 25° Left, 20°	Sloping medial epiphyses with beaklike metaphyses.	Bilateral osteotomy, July 19, 1932.	4	No	Extreme deformity necessitated operation.
2	G. M.	Female	11	12	Left	A	Varus: 15° Short: 1.5 cm.	Irregularity of epiphysis medially.	Osteotomy, June 25, 1926.	12½	Yes	Fall followed at once by a limp.
3	E. C.	Male	1	5	Left	I	Varus: 25° Short: 2.5 cm.	Lacy enlargement of metaphysis medially. Angulation below.	Operation advised.			Inward rotation of left leg on thigh.
4	F. S.	Female	2	29	Left	I	Varus: 35°	Marked bowing of proximal tibia. Thick medial cortex.	Operation advised, but refused.			Rotation, subluxation, deformity, and pain.
5	B. B.	Female	11	12	Left	A	Varus: 12° Short: 7 mm.	Narrow dense epiphysis medially with early closure.	Osteotomy, March 9, 1934.	14	No	Symptoms of strain relieved conservatively.
6	N. J.	Female	1	2½	Both	I	Varus: 15°	Sloping medial epiphyses with beaklike metaphyses.	Medical.			Overweight. Eczema during fourth to fifth months.
7	M. S.	Female	2	7	Right	I	Varus: 22° Short: 1.8 cm.	Abrupt angulation below epiphysis. Irregular epiphysis medially.	Osteotomy, June 24, 1935.	9	Slight	Rapid increase of deformity at six years.
8	H. P.	Female	2	11½	Left	I	Varus: 15° Short: 3 cm.	Abrupt angulation below epiphysis. Irregular epiphysis medially.	Osteotomy and epiphyseal arrest, March 2, 1936.	11½	No	Pain and increased bowing appeared at eleven.
9	S. A. C.	Female	1	4	Left	I	Varus: 12°	Sloping tibial epiphysis. Beaklike metaphysis.	Osteotomy, January 8, 1936.	4	No	Similar involvement of right without excessive angulation.
10	H. C.	Female	1	1	Both	I	Varus	Sloping tibial epiphyses. Beaklike metaphyses.	Braces. Operation refused.			Increase of deformity during observation.
11	A. J.	Male	1	2	Right	I	Varus: 15°	Beaklike metaphysis. Irregular density.	Observation.			Bowing of left disappeared.
12	R. W.	Male	13	21	Both	A	Varus { Right, 10° Left, 15° Shortening	Abrupt angulation below tibial heads. Epiphyses closed.	Bilateral osteotomy, April 14, 1936.	21	No	Pain and transient locking, both knees.
13	M. B.	Female	7	9	Left	A	Varus: 20° Short: 1 cm.	Narrow epiphysis. Projecting metaphysis. Abrupt angulation.				Onset following acute respiratory disease.

* I = Infantile type. Onset at the time when the child begins to walk.
A = Adolescent type. Onset at the second rapid-growth period, from eleven to thirteen years (occasionally at six or seven years).

the involvement of both cartilage and bone. These cases are similar to the other "osteochondrotrophopathies". The term is accurately descriptive of the lesion, but is too unwieldy for ordinary use. The more inclusive term "osteochondrosis" has been used by the writer. It finds a parallel in the term "arthrosis" which has come into general use in Europe. Lülsdorf's designation "deformans" has been retained to differentiate this lesion from Osgood-Schlatter disease, in which there is no gross alteration of form. "Tibia vara" is a satisfactory anatomical designation, in keeping with the terms "coxa plana" and "genu varum".

Although the condition has received scant attention, it is not nearly so uncommon as one would suppose. It deserves more general recognition and differentiation from other lesions causing deformity at the knee. Thirteen new cases are presented in tabular form in Table I. Representative summaries of a few of them will suffice to characterize the entity.

FIG. 1

Case 22. Aged seven years. Left knee.

TYPE I

INFANTILE TIBIA VARA

CASE 1. J. H., a white female, three and one-half years old, was brought in by her parents because of extreme bowing of both legs, first noted when she began to walk. Adequate cod-liver oil and orange juice had been given.

There was marked angulation of both legs into bow-leg and back-knee just below the tibial head (Fig. 2). There was moderate in-toeing, but no other evidence of rickets. The bones were hard and inelastic.

The roentgenograms (Fig. 3) showed that both proximal tibial epiphyses were deficient medially where they sloped to sharp edges instead of to rounded margins. There were beaklike medial projections of the metaphyses, at the tips of which there were small cystlike areas of rarefaction. The contours of the soft tissues suggested bulblike extension of the cartilage even beyond these points. The medial cortex was much increased in thickness on both sides. Except for the angulation mentioned, the bones of the legs were straight.

Because of the extreme deformity, on July 19, 1932, bilateral osteotomy was performed by "slivering" the shafts obliquely with overcorrection of about 10 degrees on both sides.

FIG. 2

Case 1. J. H., aged three and a half years. Before operation.

A piece of the "beak" on the right was removed for microscopic study. The report of Dr. G. H. Hansmann of Columbia Hospital was as follows: "On microscopic examination a marked distortion of trabeculae of bone at the point of junction with cartilage was observed. [See Figure 4.] The distortion seemed to be a bending of these trabeculae all in the same direction. The distortion of the epiphyseal cartilage with a bending of the bone trabeculae had pushed the periosteum outward and it had arched over the bone and cartilage. There were spicules of bone on the outer surface of the cartilage, which appeared to be independent of the bone trabeculae at the epiphyseal line. It may be that in this marked distortion osteoblasts were carried out around the cartilage and were responsible for this bone formation. The cartilage had softened in places and granulation tissue had invaded some of the softened areas, while others appeared as holes in the cartilage. [See Figure 5.] There were islands of cartilage and calcium deposit which were probably calcified cartilage in the center portion of bone trabeculae, quite remote from the epiphyseal line. That is, bone had been laid down about this cartilage without replacing it in the ossification of the trabeculae. Some of the trabeculae revealed marked osteoblastic activity about them. Diagnoses: Defective osteogenesis; mechanical deformity of bone."

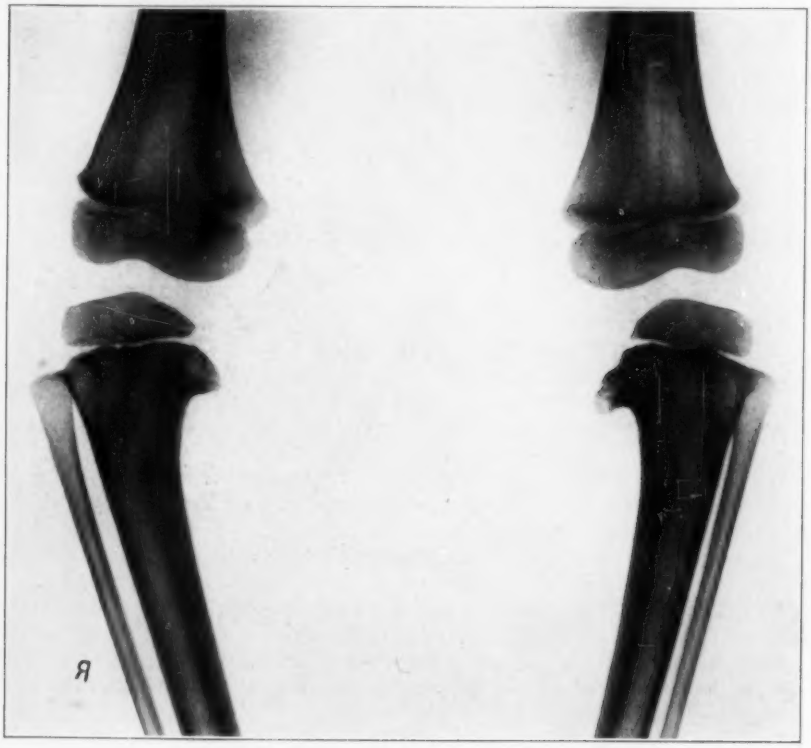

FIG. 3

Case 1. J. H., aged three and one-half years. Roentgenogram before operation.

A spica cast was applied and allowed to remain for seven weeks; following this, braces were worn for four months. A roentgenogram (Fig. 6) shows overcorrection. Figure 7 shows the appearance three months later. There was no recurrence at the end of four years.

FIG. 4

Case 1. J. H. Photomicrograph of the metaphysis, showing the distorted bone trabeculae and focal areas of marked osteogenesis.

FIG. 5

Case 1. J. H. Photomicrograph of metaphysis, showing the softened cartilage, calcification, and islands of cartilage cells in the trabeculae and bending of the bone trabeculae.

FIG. 6

Case 1. J. H., aged four years. Roentgenogram after operation.

CASE 4. F. S., a white female, aged twenty-nine, complained of bowing of the left leg and pain in the left knee. She had been a strong, healthy child and there was no history of rickets. There were no bone diseases or deformities in the family. At two years of age, both legs had become markedly bowed. Braces had been worn and the right leg had gradually straightened. Even though a brace had been worn on the left leg until the patient was fourteen years of age, the bowing persisted. There had been pain in the left knee for three years.

FIG. 7

Case 1. J. H., aged four years. Three months after operation.

There was angulation of the left leg of 35 degrees with the apex laterally and at the upper end of the tibia. The deformity was increased during weight-bearing. The tibia was rotated outward on the femur 25 degrees with slight subluxation.

A roentgenogram of the left leg (Fig. 8) showed extreme bowing of the upper end of the left tibia with superimposition of the fibula. The shaft of the tibia was greatly increased in width, and the medial cortex was three times as thick as the lateral. Osteotomy was advised, but was refused.

CASE 7. M. S., a white female, seven years old,

FIG. 8

Case 4. F. S., aged twenty-nine years. Left knee. Onset of bowing in infancy.

FIG. 8

was brought to the Milwaukee Children's Hospital on August 14, 1933 because of bowing of the right leg. She had been delivered by instruments at term. No cod-liver oil had been given. Both legs were bowed at fourteen months when she started to walk. They had straightened out somewhat at four years. At six the bowing had become much exaggerated on the right. The family history was negative.

There was abrupt bowing just below the right knee, but no other evidence of active rickets. The right leg was one centimeter shorter than the left. Roentgenograms and a tracing were made, and a brace was supplied. In spite of this, the deformity increased steadily in the next two years (Fig. 9). There was abnormal mobility of the right knee on medial strain, with angulation and shortening of one and eight-tenths centimeters. A roentgenogram (Fig. 10), taken on April 4, 1935, showed an angulation of the right tibia of 22 degrees with the apex laterally. The epiphyseal line was irregular in outline and narrower than on the left, and the medial tibial cortex was thicker.

An osteotomy was performed on June 24, 1935, because of the increasing disability. The bowing on the right was overcorrected (Fig. 11) and the knock-knee persisted for several months. After one year, a slight recurrence of the angulation made the legs straight (Fig. 12).

CASE 8. H. P., a white female, aged eleven and one-half years, of Greek parentage, was brought to the University of Chicago Clinics on February 17, 1936, because of bowing of the left leg. This had first been noted by the parents when the patient was two years of age. There had been only slight improvement as she grew older. Two years before admission, there had been pain on the medial side of the left knee, which had lasted one week. Nine months before admission, there had been an increase of the bowing and of the limp. There was nothing significant in the past or family history.

The patient walked with a considerable limp on the left. There was angulation of the left tibia, with the apex laterally, just below the knee joint with marked prominence of the fibular head (Fig. 13).

A roentgenogram of the left tibia (Fig. 15) showed irregularity and broadening of the proximal epiphyseal line medially. The distinction between the cartilage and the bone was less marked. Below the epiphysis

FIG. 9

Case 7. M. S., aged nine years. Before operation.

there was an abrupt angulation inward of 15 degrees with the apex laterally. Teleoroentgenograms showed a shortening of three centimeters on the left.

Overcorrection was obtained by an osteotomy on March 2, 1936. This was combined with epiphyseal-diaphyseal fusion of the proximal tibial and fibular epiphyses on the left. There appeared to be bony fusion between the epiphysis and the diaphysis of the left tibia medially. Epiphyseal fusion was similarly performed on the right. Good overcorrection was obtained (Fig. 16). There was no recurrence at the end of six months (Fig. 14).

TYPE A

Adolescent Tibia Vara

Case 2. G. M., a white female, twelve years of age, had fallen from a swing in June 1925, abrading the left knee. The wound had healed in four weeks, but she had limped for several weeks longer. Three months later the mother had noticed that the leg was becoming bowed; during the next six months the angulation became worse. The patient had limped for the two weeks previous to examination on January 27, 1926.

Fig. 10

Case 7. M. S., aged nine years. Roentgenogram before operation.

FIG. 11

Case 7. M. S., aged nine years. Roentgenogram of right tibia after operation.

There was no swelling, tenderness, or increased local temperature about the knee. Motions were normal. The left leg was bowed just below the knee, so that the knees were separated by two centimeters when the malleoli were together. The right tibia was thirty-two centimeters in length; the left tibia, thirty and six-tenths centimeters.

A roentgenogram (Fig. 24-A) showed an irregularity of contour of the left proximal tibial epiphyseal line with abrupt angulation at the metaphysis with the apex laterally. Except for the modified pattern of the lines of stress, there was no abnormality of the bone.

A brace relieved the pain and was worn for six months. An osteotomy was performed on June 25, 1926, at twelve and one-half years of age. After eight weeks, the cast was replaced by a brace. The legs were symmetrical. The length of the right leg was seventy-nine and four-tenths centimeters; that of the left, seventy-six and six-tenths centimeters. In a telephone conversation two years later, it was learned that the deformity had partially recurred.

FIG. 11

CASE 5. B. B., a white female, was twelve years old when first seen on November 3, 1932, because of a limp on the left, and aching of the left foot and knee. The symptoms had first appeared a year and one-half previously, following a sprain of the left ankle. In the spring of 1932, bowing of the left leg had been observed. Just before the examination, the symptoms became worse.

A well-nourished, athletic girl, the patient was normal in every way except for the left leg, which was bowed abruptly just below the knee. The symptoms were largely due to the relative flat-foot and foot strain on the left. There was increased mobility of the knee joint on medial strain and slight bilateral recurvatum. The length of the right leg was eighty-five and three-tenths centimeters; that of the left, eighty-four centimeters. The difference was greater on weight-bearing. Symptomatic treatment relieved the aching, and the limp disappeared.

A roentgenogram of both knees (Fig. 17) showed an angulation of 12 degrees with the apex laterally at the proximal end of the left tibia. The epiphyseal line was more nearly closed than on the right and was irregular in contour medially. These changes were not striking, and the bones were otherwise normal.

When the patient was fourteen years of age, an osteotomy of the left tibia was performed, for cosmetic

FIG. 12

Case 7. M. S., aged ten years. Six months after operation.

reasons, on March 9, 1934. A plaster spica was applied with the leg in a position of overcorrection. A crutch was added a few days later. In this peg-leg cast [6], the patient walked about during her convalescence. Two years later there had been no recurrence (Fig. 18). The legs measured the same length, and a slight left total scoliosis had entirely disappeared. The slight increase in mobility of the knee joint on medial strain was the only residuum, but this caused no disability.

FIG. 13

Case 8. H. P., aged eleven and one-half years. Before operation.

CASE 13. M. B., a white female, nine years old, gave a history of a bowleg on the left at seven years of age, shortly after a severe respiratory infection. There had been a gradual increase of the deformity. Pain had appeared over the head of the left fibula after long walks. There had

FIG. 14

Case 8. H. P., aged twelve years. After operation.

FIG. 15

Case 8. H. P., aged eleven and one-half years. Left knee before operation.

FIG. 16

Case 8. H. P., aged eleven and one-half years. Roentgenogram after osteotomy and epiphyseal fusion.

been some bowing of the right leg just prior to examination. There was nothing of importance in the past or family history.

The examination was negative except for the bow leg on the left (Figs. 19-A and 19-B). There was marked angulation just below the knee, but the tibia was straight distal to this point. The same was true of the right leg to a lesser degree. The left leg was one centimeter shorter than the right. The reflexes and circulation were normal.

In the roentgenogram (Fig. 20) the height of the proximal tibial epiphyses was less medially than normal. On the left, the medial margin was rounded off and was narrower than the lateral margin. The metaphysis projected in the form of a sharp beak. There was abrupt angulation of the shaft of the tibia of 20 degrees with the apex medially. There was no diminution of the joint interval, and no gross irregularity of the epiphyseal line.

The salient features in the cases from the literature have been tabulated for the sake of brevity in Table II.

For comparison, it was thought advisable to present tracings of the roentgenograms of the new cases and tracings of those from the literature. Only the anteroposterior views have been used because, where available, the lateral added little to our knowledge. The tracings (Figs. 21 to 25 inclusive) have been grouped according to similarity of appearance.

FIG. 17
Case 5. B. B., aged twelve years.

THE INFANTILE GROUP

The tracings in Figures 21, 22, and 23 are similar in appearance and suggest a common etiology. Cases 19, 21, and 27, however, must be excluded because of the history of late onset and placed in the adolescent group. Cases 4, 7, and 26 (Fig. 24) are quite different in appearance, but must be included with the first group because of the onset of bowing in infancy.

Twenty cases are of the infantile type. There were seventeen females and two males and in one case the sex was not recorded. In each case there was a history of normal development to the age of from one to two years, usually with some overweight. Then the exaggerated physiological bow-leg [7], instead of developing gradually into the normal knock-knee, became more marked. This increase in deformity was bilateral in nine cases, on the left side only in seven, and on the right side only in four. Rickets could be ruled out in most cases and was not prominent in any case. No likely etiological factors were suggested by the history or by the associated findings.

Roentgenograms were so uniform in appearance as to suggest a common cause. Figure 26-B shows diagrammatically the abrupt angulation (*A*) just below the proximal tibial epiphysis, the medially expanded, some-

FIG. 18

Case 5. B. B., aged sixteen years. Two years after operation.

FIG. 19-A

FIG. 19-B

Case 13. M. B., aged nine years.

FIG. 20

Case 13. M. B., aged nine years.

TABLE II

SUMMARY OF CASES FROM THE LITERATURE

Case No.	Year	Writer	Country	Sex	Age		Side	Type *	Deformity
					At Onset (*Years*)	When Seen (*Years*)			
14	1899	Kirmisson	France	Female	13	20	Left	X	Varus
15	1922	Erlacher	Austria	Female	1½	2½	Left	I	Varus: 30°
16	1922	Valentin	Germany	Female	4	7	Left	X	Varus Short: 2 cm.
17	1922	McCurdy	United States				Both	I	Varus
18	1924	Mau	Germany	Female	Birth	6	Right	I	Varus: 15° Short: 1 cm.
19	1928	Langenski ld	Finland	Male	11	11	Right	A	Varus
20	1928	Nilsonne (Case 1)	Sweden	Female		7	Both	I	Varus
21	1928	Nilsonne (Case 2)	Sweden	Male	7	8	Left	A	Varus
22	1929	Lewin and Ritter	United States	Female	Birth	7	Left	I	Varus: 20°
23	1929	Rall (Case 1)	Germany	Female	Birth	8	Both	I	Varus
24	1930	Lülsdorf (Case 1)	Germany	Female	8	9	Left	A	Varus: 20° Short: 2 cm.
25	1930	Lülsdorf (Case 2)	Germany	Female	11	12	Left	A	Varus Short: 2 cm.
26	1930	Lülsdorf (Case 3)	Germany	Female	Birth (?)	10	Left	I	Varus
27	1930	Rocher and Roudil	France	Female	6	8	Right	A	Varus: 15° Short: 1 cm.
28	1932	Maselli (Case 1)	Italy	Male	3	13	Right	X	Valgus Short: 4 cm.
29	1932	Maselli (Case 2)	Italy	Male	13	17	Right	X	Valgus Short: 5 cm.
30	1933	Gickler (Case 1)	Germany	Male	8	10	Left	X	Short: 2 cm.
31	1933	Gickler (Case 2)	Germany	Male			Right	X	Short: 2 cm.
32	1933	Van Gelderen	Holland	Female	5	8	Left	X	Short: 1½ cm. Varus
33	1934	Rall (Case 2)	Germany	Female	1	2	Both	I	Varus
34	1936	Sloane, Sloane, and Gold (Case 1)	United States	Female	2	6	Both	I	Varus
35	1936	Sloane, Sloane, and Gold (Case 2)	United States	Female	Birth	7	Both	I	Varus
36	1936	Sloane, Sloane, and Gold (Case 3)	United States	Female	Birth	4	Right	I	Varus

* I = Infantile type. Onset at the time when the child begins to walk.
A = Adolescent type. Onset at the second rapid-growth period, from eleven to thirteen years (occasionally at six or seven years).
X = Cases which have been included by other writers, but in which the affection appears to be obviously secondary or of a different character.

TABLE II (*Continued*)

SUMMARY OF CASES FROM THE LITERATURE

Suggested Etiology	Roentgenographic Findings	Treatment	Age at Operation (*Years*)	Recurrence	Remarks
Late rickets	Angulation below proximal tibial epiphysis.				Also right genu valgum and right dorsal scoliosis.
Congenitally predisposed	Epiphysis deficient medially; beaklike rarefied metaphysis.	Curved osteotomy	2½	No	Father had arthritis deformans of left hip at twenty-seven.
Chronic osteomyelitis	Epiphysis patchy and deficient medially.	Osteotomy in 1921	7		Pain and swelling in right ankle and left middle finger.
Perthes-like	Angulation with beaklike medial metaphysis.				No discussion. Only x-ray presented.
Cartilaginous exostoses	Sloping epiphysis medially and beaklike metaphysis.	Osteotomy in 1923	6		No other deformity of skeleton.
Perthes-like	Broad, hazy epiphyseal line medially with abrupt angulation.	Curved osteotomy suggested			Gradual narrowing of epiphyseal line in five years.
Unclassified growth disturbance	Sloping epiphysis medially; beaklike metaphysis.	Osteotomy in December 1926	7		Entire skeleton otherwise negative to x-ray.
	Low epiphysis medially with enlarged metaphysis.				Destructive process in left hip preceded that of knee by three years.
Perthes-like	Sloping epiphysis, obscured line, and beaklike metaphysis.	Osteotomy	7	Yes	Both legs very bowed until four years.
Perthes-like	Sloping epiphysis medially with beaklike metaphysis.	Osteotomy in January 1928 Osteotomy in September 1928	8	Yes	Not at first overcorrected.
Inflammatory process of epiphysis	Irregular defect of medial epiphyseal line.				No other symptoms, but bowing and limp.
	Epiphyseal line medially irregular in shape and density.				Intermittent attacks of pain.
	Rarefaction and irregularity of epiphyseal line medially.	Osteotomy in April 1925 Osteotomy in July 1927	11 13	Yes Yes	Bilateral at first. More marked on left.
Congenital hypoplasia	Agenesis of medial epiphysis with beaklike metaphysis.	Osteotomy in January 1928 Osteotomy in November 1929	8 10	Yes	Rapid recurrence after first correction.
Infection	Localized increased density of epiphyseal line.	Wedged cast			Smallpox at thirteen months.
	Epiphyseal line wide on medial side.	Medical			Typhoid fever preceded the onset.
Vitium primae formationis	Narrow dish-shaped epiphyseal line with irregular epiphysis.				Patella bipartita.
	Marked narrowing of epiphysis medially.				Femoral epiphysis irregular, bipartite patella.
Perthes-like	Epiphyseal line dish-shaped, but not irregular.				Pain when kneeling.
Perthes-like; congenital predisposition	Beaklike recurving metaphysis.				Pain and disability for a few days.
Dyschondroplasia	Sloping fragmented medial epiphysis; beaklike metaphysis.				More marked on the right.
Dyschondroplasia	Sloping medial epiphysis; beaklike metaphysis.	Biopsy			Failure of growth differentiation and ossification of cartilage cells.
Dyschondroplasia	Sloping fragmented medial epiphysis; beaklike metaphysis.				

times irregular epiphyseal line (*B*), the wedge-shaped epiphysis (*C*), and the prominent, beaklike, recurving, medial metaphysis (*D*). Within the beak are the cartilage islands (*E*). Over the bony prominence there is hyaline cartilage and over this the soft parts form an additional enlargement. This may be palpated as a bulbous prominence, but it is not an exostosis as described by Mau and suggested by a hasty look at the roentgenogram.

THE ADOLESCENT GROUP

The nine cases of the second group are typified by Cases 2, 5, 24, and 25 (Fig. 24). The onset was between six and twelve years of age in previously normal children. Cases 14 and 28 (Fig. 25) might be classed with these, but they are not included because of multiplicity of lesions in Case 14 and the occurrence of valgus instead of varus in Case 28. In Cases 2, 5, and 24 (Fig. 24) trauma was a likely exciting cause. Cases 19, 21, and 27 are somewhat similar in roentgenographic appearance to the infantile group, but they must be included here instead because the deformity did not appear during infancy.

Cases 30 and 32 (Fig. 25) are strikingly similar in appearance. The onset at eight and five years respectively associates them as to etiology. The shortening was relatively the same in both. In Case 32 the patient had some pain in the left leg at eight months, but after five weeks her condition was normal again and remained so until five years later, when pain returned and swelling appeared. In Case 30 there is no etiology suggested other than the inevitable trauma of football which was a favorite sport with the boy. Here the presence of a bilateral patella bipartita raised the question of a congenital factor. Case 31 was reported by Gickler as a growth disturbance similar to that of Case 30. The femur is likewise involved, however, and the defective appearance of the adjacent epiphyses has little in common with the other cases. It is the only one in which the epiphyseal line is not disturbed. The association of a patella bipartita suggests a developmental defect of the right knee joint.

The deformity in Case 29 closely followed typhoid fever, and in Case 16 there was pain and swelling of the knee, associated with bone infection elsewhere. These seem to have been secondary lesions.

In Case 21 the deformity of the left knee appeared at seven years of age, two years following a destructive lesion of the right acetabulum. The appearance of the two lesions is described as quite different. It seems logical to regard the influence of the hip lesion as mechanical. The relative lengthening of the left leg must have thrown considerable strain on the medial aspect of the left knee. This strain at the age of seven could conceivably be the exciting cause of an epiphyseal disturbance. If the hip lesion was an osteochondromatosis of the ilium, as suggested by Nilsonne, it is possible that both were manifestations of the same process.

ETIOLOGY

Like the blind men, who, in turn, described the elephant as a rope, a

FIGURE 21

TRACINGS OF CASES WITH UNILATERAL INVOLVEMENT AND SIMILAR ROENTGENOGRAPHIC APPEARANCE SUGGESTING EARLY ONSET

FIG. 21-A
Case 3. Patient E. C.

FIG. 21-B
Case 15. Reported by Erlacher.

FIG. 21-C
Case 18. Reported by Mau.

FIG. 21-D
Case 21. Reported by Nilsonne (his Case 2).

FIG. 21-E
Case 22. Reported by Ritter and Lewin.

FIG. 21-F
Case 27. Reported by Rocher and Roudil.

FIG. 21-G
Case 36. Reported by Sloane, Sloane, and Gold (their Case 3).

tree, a fan, etc., writers disagree as to the etiology. One will see an osteochondral lesion following injury, and for him the general cause is trauma. Another cultures the streptococcus from a biopsy specimen and concludes that infection is the usual cause. We hear embolism, ischaemia, and endocrine dysfunction suggested as explanations. Since Müller described coxa vara in 1888, there has been much speculation as to the cause of such juxta-epiphyseal lesions on the basis of individual experience. Lewin, Buchman, Harbin and Zollinger, and others in recent years have done much to clarify and to correlate our knowledge. The earlier bogy

FIGURE 22

TRACINGS OF BILATERAL INFANTILE CASES AND OF ONE ADOLESCENT CASE (FIG. 22-D) TO SHOW THE CHANGES IN APPEARANCE WITH ADVANCING AGE

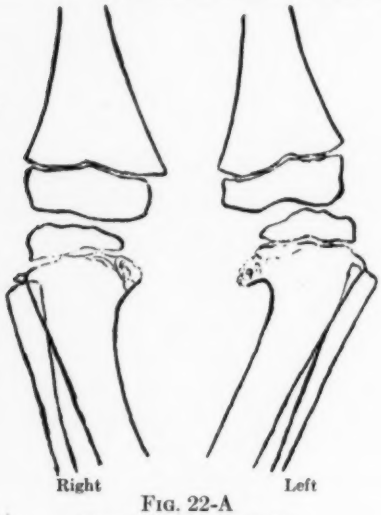

FIG. 22-A
Case 1. Patient J. H.

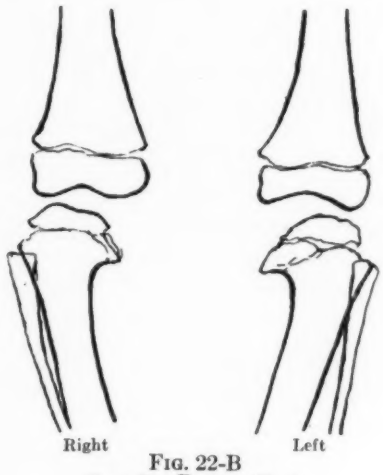

FIG. 22-B
Case 6. Patient N. J.

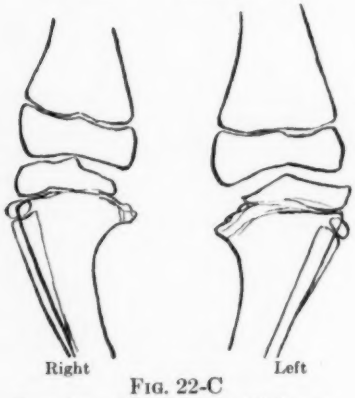

FIG. 22-C
Case 17. Reported by McCurdy.

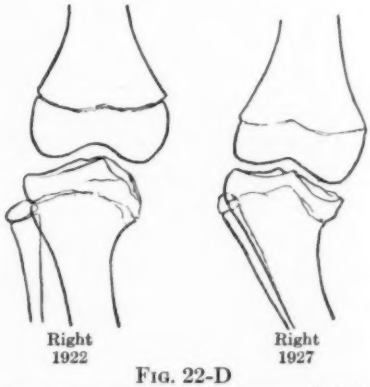

FIG. 22-D
Case 19. Reported by Langenskiöld.

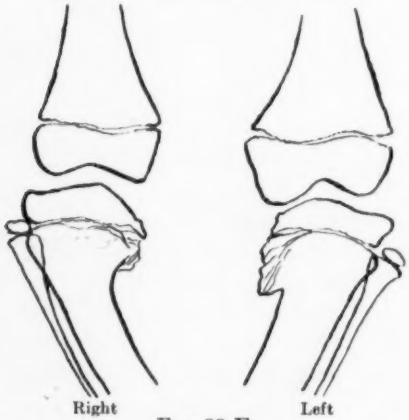

FIG. 22-E
Case 20. Reported by Nilsonne (his Case 1).

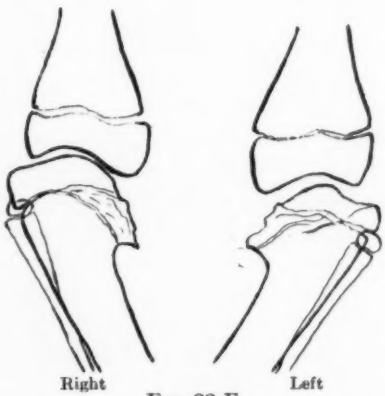

FIG. 22-F
Case 23. Reported by Rall (his Case 1).

FIGURE 23

TRACINGS OF BILATERAL CASES OF THE INFANTILE TYPE

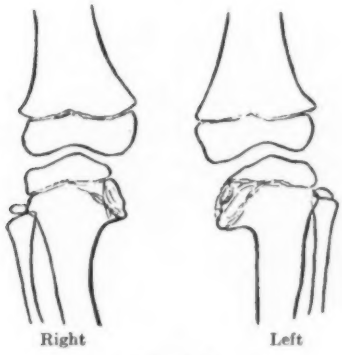

FIG. 23-A
Case 9. Patient S. A. C.

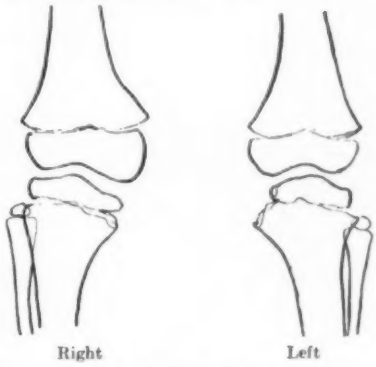

FIG. 23-B
Case 10. Patient H. C.

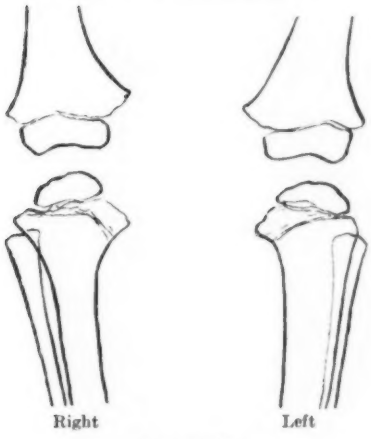

FIG. 23-C
Case 11. Patient A. J.

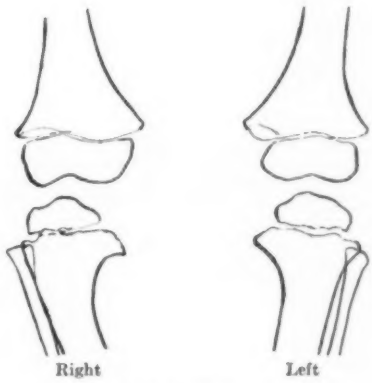

FIG. 23-D
Case 33. Reported by Rall (his Case 2).

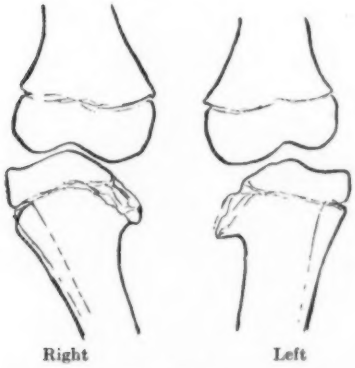

FIG. 23-E
Case 34. Reported by Sloane, Sloane, and Gold (their Case 1).

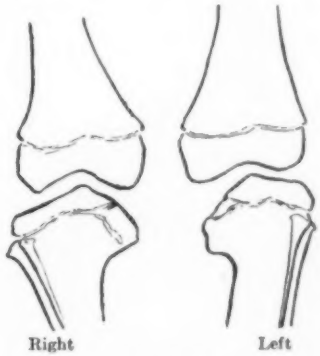

FIG. 23-F
Case 35. Reported by Sloane, Sloane, and Gold (their Case 2).

FIGURE 24

TRACINGS OF OLDER SUBJECTS. THE ADOLESCENT TYPE PREDOMINATES BUT CANNOT BE DISTINGUISHED FROM THE INFANTILE BY ROENTGENOGRAPHIC APPEARANCE

FIG. 24-A
Case 2. Patient G. M.

FIG. 24-B
Case 4. Patient F. S.

FIG. 24-C
Case 5. Patient B. B.

FIG. 24-D
Case 7. Patient M. S.

FIG. 24-E
Case 8. Patient H. P.

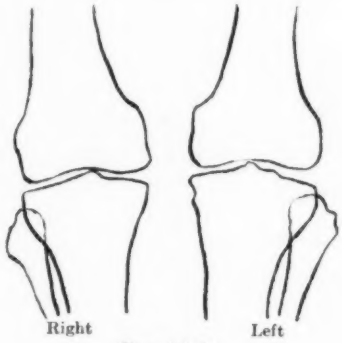

FIG. 24-F
Case 12. Patient R. W.

FIG. 24-G
Case 13. Patient M. B.

FIG. 24-H
Case 24. Reported by Lülsdorf (his Case 1).

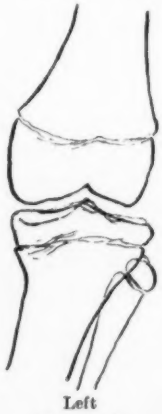

FIG. 24-I
Case 25. Reported by Lülsdorf (his Case 2).

FIG. 24-J
Case 26. Reported by Lülsdorf (his Case 3).

FIGURE 25

TRACINGS OF MISCELLANEOUS CASES REPORTED ELSEWHERE BUT DIFFERING RADICALLY FROM TIBIA VARA

FIG. 25-A
Case 14. Reported by Kirmisson.

FIG. 25-B
Case 16. Reported by Valentin.

FIG. 25-C
Case 28. Reported by Maselli (his Case 1).

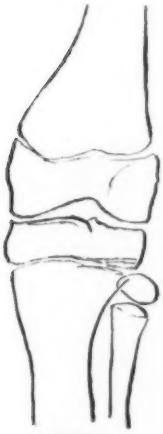

FIG. 25-D
Case 29. Reported by Maselli (his Case 2).

FIG. 25-E
Case 30. Reported by Gickler (his Case 1).

FIG. 25-F
Case 31. Reported by Gickler (his Case 2).

FIG. 25-G
Case 32. Reported by Van Gelderen.

men of causation of this group of diseases have been overthrown one by one.

Rickets used to be blamed for all deformities without other obvious causes. Accurate determinations of the calcium and phosphorous content of the serum have shown them to be normal in various forms of osteochondrosis [11]. Although angulation at the proximal tibial epiphysis can, of course, be the result of rickets, bowing is more frequent than angulation in this disease. In the cases of this series there is nothing in the clinical or roentgenographic findings to suggest rickets.

Hass [22] shows a line drawing which is typical of the adolescent type of osteochondrosis deformans tibiae, but he ascribes the condition to late rickets. This entity may have been a frequent cause of knock-knee and bow-leg in his experience, but we do not see late rickets in the United States. In an admirable review of this disease, Looser published a case with involvement of the medial portion only of the proximal tibial epiphysis. When the late rickets had healed, the deformity would have been indistinguishable from those of the adolescent type of tibia vara. In the active stage, however, one would not have missed in the roentgenogram the clear zone of rarefaction at the epiphyseal line. In 1899, Kirmisson published a case of multiple deformities beginning at the age of thirteen in a girl who had been previously normal. The right knee was angulated into valgus of 150 degrees at the lower epiphysis of the femur. On the left side, a genu varum was the result of an abrupt angulation at the upper tibial epiphysis. These deformities, with a right dorsal scoliosis, were ascribed to late rickets, a term which Kirmisson used synonymously with rickets. The reproductions of the roentgenograms were, of course, poor according to our present standards, but they showed no clear zone of rarefaction at the epiphyseal line which would characterize the lesion as true late rickets. There was no history of dietary deprivation such as usually precedes this disease, but the age of onset and the distribution of lesions were typical. The case was mentioned by several of the other writers and is included in Table II under the grouping "X".

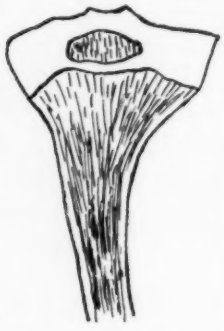

FIG. 26-A

Roentgenogram of the tibia of a three-year-old child. (Redrawn from Böhm [8].)

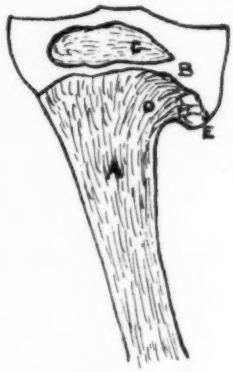

FIG. 26-B

Case 1. Aged three and one-half years. Tracing from the roentgenogram with the cartilage restored. *A:* shaft angulated; *B:* widened epiphyseal line; *C:* wedge-shaped epiphysis; *D:* beaklike metaphysis; *E:* cartilage islands.

With hereditary deforming cartilaginous exostoses one frequently observes a similar angulation at the level of a bony spur. It is easy to understand Mau's confusion of his case with those of Bessel-Hagen and Pels-Leusden. In infantile tibia vara, however, the apparent exostosis is in reality a bulbous prominence. Chondrodysplasia without exostoses [5] is even more confusing. The local condition might well be mistaken clinically for osteochondrosis deformans tibiae. However, the large metaphyseal islands of cartilage, which are characteristic of this disease, would serve to establish the diagnosis in the roentgenogram.

Infection is blamed by Valentin, Lülsdorf, and Maselli. Probably the deformity in Valentin's case (Case 16) was secondary to infection and this case should be excluded from the group. A similar deformity

may follow frank osteomyelitis [3] at the proximal tibial epiphysis. Maselli's cases (Cases 28 and 29) differ from the others in the direction of the angulation. In the first, there is a history of smallpox two years before the appearance of the knock-knee; in the second, typhoid fever preceded the onset of the knock-knee by eighteen months. These infections may have played an etiological rôle, but the evidence is inconclusive. Lülsdorf considers the deformity to be the sequela of the inflammation of the epiphysis resulting in premature ossification or secondary calcium deposit. There is some evidence to substantiate this suggestion of inflammation. Premature ossification is a constant finding in the adolescent group. Coxa plana has similarly been called by many writers a chronic low-grade osteomyelitis. Pyogenic organisms were isolated after operation by Phemister, Brunschwig, and Day; Kidner; McWhorter; and others.

Fracture into the epiphyseal line will occasionally cause bowing. Growth arrest has followed operations and the use of skeletal traction with encroachment on this cartilage. Following the eradication of a giant-cell tumor of the upper end of the tibia by Putti, a characteristic angulation appeared which looked in the published roentgenogram [43] like the condition under discussion.

Multiplicity of lesions does not rule out tibia vara. The writer has seen simultaneously osteochondroses of the patella, both lower femoral epiphyses, and several secondary spinal centers. A number of multiple osteochondroses have been reported. Naturally such multiplicity is rare when the age of development of each osseous center is different. Nilsonne's Case 2 (Table II, Case 21) and even those cases of Kirmisson and Valentin may have been multiple osteochondral lesions of this type.

Gickler reports two quite different cases as "growth disturbances" and blames a *vitium primae formationis*. He recognizes the similarity to the parallel lesions of the lower femoral epiphysis which give rise to a genu valgum. He compares his cases to those of Lülsdorf. It seems, rather, that his Case 1 (Table II, Case 30, Fig. 25-E) was strikingly like that of Van Gelderen (Case 32, Fig. 25-G) and that his Case 2 (Table II, Case 31, Fig. 25-F) should not be included in this series at all. His Case 1 differs from all of the rest except Cases 28 and 32, in that the epiphyseal line is curved like a dish instead of a dome in the anteroposterior view. This would locate the site of the epiphyseal arrest at the center rather than medially or laterally. In Van Gelderen's case the lesion was slightly to the medial side, giving rise to a varus. Maselli's Case 1 (Table II, Case 28, Fig. 25-C) suggests a similar but less extensive involvement somewhat lateral to the middle but not at the lateral border as in his Case 2 (Table II, Case 29, Fig. 25-D).

Erlacher recognizes the similarity of this lesion to the other osteochondroses and suggests a congenital predisposition as the predominant etiological factor. McCurdy, Langenskiöld, Rall, Rocher and Roudil, and Van Gelderen are satisfied to liken the condition to coxa plana and to presume the same etiology.

In the thirteen cases reported here, and in at least fifteen of those from the literature, there is no evident cause. The epiphyseal lesion must be considered primary in the infantile type. To liken the deformity to coxa plana does not solve the problem of etiology, for the cause of this trophopathy of the capital epiphysis of the femur is undetermined. It does help to identify the cases shown in Figures 21 to 24 inclusive to place them with this group. Speculation as to the probable cause is interesting but not conclusive.

The influence of trauma was early suggested by Legg and has been observed by numerous writers since. There are many cases in which direct trauma has caused a lesion indistinguishable from Osgood-Schlatter disease. Anzilotti even claims that osteochondrosis of the tibial tubercle is not a specific entity. Indirect trauma is certainly the exciting cause in most cases. Indirect trauma may also be the cause of direct cartilage injury or of vascular damage in the proximal tibial epiphysis sufficient to give rise to the changes in the adolescent type of tibia vara. In Cases 2 and 5 there was a definite history of injury three to six months preceding the onset of bowing. In Cases 24 and 25 the possible significance of trauma is as great as that of inflammation.

When a congenital dislocation of the hip is reduced in infancy there may be an immediate change in the capital epiphysis suggestive of coxa plana. On the other hand, the hip may seem entirely normal clinically and roentgenographically until adolescence, when the osteochondral change suddenly occurs. From a roentgenogram taken after puberty it is impossible to tell at what age the deforming process was active. We may be dealing here with a similar lesion. Tibia vara may become apparent as an arrest[10] of the normal development of the leg with exaggeration rather than diminution of the bowing during the first rapid-growth period. Figures 26-A and 26-B show a normal proximal tibial epiphysis at three years in comparison with a tracing of the roentgenogram in Case 1. The hereditary factors mentioned by Nussbaum, Jansen, and Calot fit in with this developmental hypothesis.

A similar deformity may occur at the second rapid-growth period as the result of an epiphyseal disturbance following some minor insult. The occurrence of trauma or infection may be proved, but the *modus operandi* is still uncertain. An x-ray taken later in life, as in Case 4, cannot determine the age at which the process was active.

One reaches the obvious conclusion that the occurrence of osteochondral lesions in general, and those of the proximal tibial epiphysis in particular, is dependent primarily upon the age of the patient and secondarily upon a number of factors. A congenital factor seems to operate when the deformity appears in the first years of life. Later, trauma seems to be the most potent factor with chronic infection a possible second, as suggested by Calvé. The appearance of the lesion clinically and roentgenographically depends a great deal more upon the age at which the noxious influence operates than upon the exact nature of the interference.

The corresponding but less frequent lesion at the lower end of the femur might well be called femur valgum (or varum) or osteochondrosis deformans femoris to differentiate it from coxa plana. Such cases have been recorded by Riedel, Guildal, and Hass [21]. The lesion usually results in knock-knee but occasionally in bow-leg.

PATHOLOGY

In the infantile form the changes consist essentially in faulty growth of the epiphyseal cartilage and delayed ossification of the medial portion of the proximal tibial epiphysis. A beaklike projection of the metaphysis forms secondarily as a buttress under the epiphysis.

In the beaklike prominence, areas of rarefaction are visible roentgenographically. In the microscopic section (Fig. 5) these are seen to be islands of hyaline cartilage such as Perthes described in the bone subjacent to the epiphyseal line of the femoral neck. The cells are irregular in distribution rather than columnar as they should be in a normal epiphysis. The appearance is strikingly like that of a localized chondrodysplasia. The term could better be applied here than achondroplasia, as suggested by Gonzales-Aguilar. Both, however, are already used to designate clinical entities which are distinct from the one under consideration.

The adolescent type looks different in the roentgenogram. It is an arrest of epiphyseal growth, rather than a dysplasia. The difference in pathology is more apparent than real, however. The age of the patient has more to do than the exciting cause with the appearance of the lesion. In support of this fact are the changes occurring in Case 19 (Fig. 22). The first tracing is suggestive of the infantile type and the second, after five years, of the adolescent. Presumptive evidence is even more striking in Case 4 (Fig. 24). The history here is typical of the infantile type. The roentgenogram, taken at twenty-nine years of age, shows nothing to distinguish it from the cases in which angulation appeared at eleven years of age.

SYMPTOMS

The symptoms are independent of the age at onset. Gradually increasing bowing occurs without apparent cause and without the other symptoms of rickets. The deformity is likely to appear bilaterally in the infantile cases, frequently with subsequent spontaneous disappearance of the bow-leg on one side. In the adolescent group the angulation usually occurs only on one side. There is a limp in the unilateral cases and a waddle in the bilateral. Pain from strain may be present in the knee or foot of the affected leg.

There is an abrupt angulation with the apex laterally just below the knee joint, but in fat children this appears to be a gradual curve. When the deformity appears in infancy, a bulbous enlargement of the medial condyle is palpable. Internal rotation of the tibia on the femur is a constant finding. Recurvatum and relative flat-foot are present irrespec-

tive of the age. Shortening of from one to two centimeters is usual. Abnormal mobility of the knee on medial strain with normal stability on lateral strain is a constant finding. Relaxation of the medial supportive structures of the knee persists for some time after correction of the deformity by osteotomy. This specific laxity is inaccurately termed "*Schlottern*" by the German writers. A slight effusion into the joint may result from the strain, but in those cases with marked pain and swelling the deformity must not be classed with the osteochondroses.

General medical examination is negative. There are no findings suggestive of rickets, tuberculosis, or syphylis, and specific tests for the last two are negative.

TREATMENT

As in the other osteochondroses, the deformity of the osseous center is more pronounced than that of the epiphyseal cartilage. Spontaneous healing with restitution of normal contours of the end of the bone may occur as in coxa plana. The likelihood of such an outcome has not been shown to be increased by the use of braces or of other types of support. Symptomatic mechanical relief of the relative flat-foot and knee strain are always indicated. This may be all that is necessary in the mild case. Where actual shortening is present, mechanical equalization of the length of the legs may diminish the limp. If possible, these conservative measures should be continued during a period of observation of several years. When the deformity remains stationary osteotomy should be performed,—in adolescents for cosmetic reasons and in adults when function is greatly disturbed.

The exact time for operation must be determined in each case. If the epiphyseal line is actually damaged, the deformity will become progressively worse until after the epiphysis is closed. In the late cases it is well, therefore, to wait until this time. The infantile type seems to remain stationary after three or four years as though the interference with growth had been temporary. As illustrated by Case 1, there is the possibility of lasting correction following early osteotomy. As typified by Cases 26 and 27, repeated recurrences may supervene. A guarded prognosis is the only safe one.

The curved osteotomy suggested by Langenskiöld is ingenious but not necessary in most cases. It has the theoretical advantage of adding length. Correction of the bow-leg diminishes the shortening. In young children one is likely to obtain additional length from any osteotomy by virtue of the attendant stimulation of bone growth. If properly executed, the simple transverse division also adds length by angulation. If a bone wedge is inserted, a simple leg cast with the knee slightly flexed will suffice. With a peg-leg spica, the bone wedge may be omitted and ambulation allowed without crutches.

The possibility of arrest of the growth of the epiphysis on the opposite side, according to the technique of Phemister, was considered. This

would add to the shortening, however, and really would be less desirable than osteotomy, which would increase the length. Compere, in Case 8, fused not only the proximal tibial and fibular epiphyses on the affected side in combination with osteotomy, but also those on the sound side.

Recurrence must be attributed in part to the progressive nature of the deformity. In Cases 2, 22, and 23 there was an additional factor. The abnormal mobility on medial strain of the knee absorbed about half of the angulation. What appeared to have been overcorrection turned out to be incomplete reduction of the deformity when the cast was removed.

Not appreciating the above facts, several of the writers have blamed the lack of postoperative support for the recurrence of the deformity. After solid bony union has occurred, there is little need for further fixation. Overcorrection must be maintained until this time, however.

SUMMARY

1. Thirteen new cases and fifteen from the literature illustrate the occurrence of an osteochondrosis similar to coxa plana and Madelung's deformity, but located at the medial side of the proximal tibial epiphysis.

2. The resulting abrupt angulation into varus with back-knee and internal rotation of the leg is usually confused with rickets.

3. The roentgenographic and pathological changes are like those of coxa plana and similar to those of chondrodysplasia, but quite different from those of rickets.

4. The changes may appear in the first year or two of life (infantile type) as a developmental exaggeration of the normal, with sloping epiphysis and beaklike recurving metaphysis.

5. A similar deformity may occur just before puberty (adolescent type), secondary probably to local trauma or possibly to infection.

6. The age at which the deformity is observed is more important than the causative factor in determining the roentgenographic appearance.

7. The roentgenographic findings of the infantile type gradually change to those of the adolescent, so that the two can be distinguished later only by the history.

8. Treatment should be directed toward the mechanical relief of strain until the deformity is stationary or until the epiphysis is closed.

9. A simple osteotomy is desirable in the correction of marked deformity. If it is done before the amount of angulation has become stationary, some degree of recurrence may be anticipated.

For the use of their cases, the writer is grateful to Dr. F. J. Gaenslen, Dr. H. C. Schumm, Dr. O. R. Ritter, Dr. E. L. Compere, Dr. C. H. Hatcher, Dr. H. W. Wirka, Dr. R. P. Montgomery, and Dr. V. L. Hart. Critical discussion of the material by Dr. D. B. Phemister and many others has been invaluable.

REFERENCES

1. Anzilotti, Giulio: Contributo alla patologia delle cartilagini interepifisarie. (Nota preliminare.) Arch. di Ortop., XLI, 473, 1926.

2. Asplund, G.: A Few Cases of Ischio-Pubic Osteochondritis. Acta Chir. Scandinavica, LXVII, 1, 1930.
3. Bailleul, L. C.: Déformation du membre inférieur consécutive à une ostéite de l'extrémité supérieure du tibia. Rev. d'Orthop., III, 75, 1912.
4. Bessel-Hagen, Fritz: Ueber Knochen- und Gelenkanomalieen insbesondere bei partiellem Riesenwuchs und bei multiplen cartilaginären Exostosen. Arch. f. klin. Chir., XLI, 420, 1891.
5. Blount, W. P.: Chondrodysplasia. An Unusual Case. Am. J. Dis. Child., XL, 327, 1930.
6. Blount, W. P.: The Peg Leg Cast. J. Bone and Joint Surg., XIII, 107, Jan. 1931.
7. Böhm, Max: Physiologische Deformitäten des Beins. Acta Chir. Scandinavica, LXVII, 178, 1930.
8. Böhm, Max: Entstehung der kindlichen Beindeformitäten. Ztschr. f. orthop. Chir., LIII, 377 (S. 383, Abb. 7), 1931.
9. Böhm, Max: Das kindliche Genu (Crus) varum. Chirurg, IV, 913, 1932.
10. Böhm, Max: Das menschliche Bein. Seine normale Entwicklung und die Entstehung der Wuchsfehler (Hüftluxation, X- und O-Beine, Knick- und Plattfüsse, Klumpfuss). S. 112–125. Stuttgart, Ferdinand Enke, 1935.
11. Buchman, Joseph: A Résumé of the Osteochondritides. Surg. Gynec. Obstet., XLIX, 447, 1929.
12. Calot, M.: L'équation "ostéochondrite=subluxation congénitale", prouvée sur une radio pour laquelle nous avons été consulté par une Université allemande qui a adopté notre conclusion. Extrait des Comptes Rendus du 41 Congrès de l'Association Française de Chirurgie, 1932.
13. Calvé, Jacques: Osteochondritis of the Upper Extremity of the Femur. J. Orthop. Surg., III, 487, Oct. 1921.
14. Compere, E. L.: Personal communication.
15. Erlacher, Philipp: Deformierende Prozesse der Epiphysengegend bei Kindern. Arch. f. Orthop. u. Unfall-Chir., XX, 81, 1922.
16. Gickler, H.: Wachstumsstörungen der Tibiaepiphyse. Arch. f. Orthop. u. Unfall-Chir., XXXII, 20, 1932.
17. Gonzales-Aguilar, J.: La osteocondritis de los centros de crecimiento. An. Casa de Salud Valdecilla, III, 231, 1932.
18. Guildal: Zwei Fälle von Genu valgum mit etwas eigentümlicher Ätiologie. Acta Chir. Scandinavica, LXIV, 199, 1929.
19. Hackenbroch, M.: Das atypische Genu varum. Acta Chir. Scandinavica, LXVII, 448, 1930.
20. Harbin, Maxwell, and Zollinger, Robert: Osteochondritis of the Growth Centers. Surg. Gynec. Obstet., LI, 145, 1930.
21. Hass, Julius: Konservative und operative Orthopädie. 1 Aufl., S. 246. Vienna, Julius Springer, 1934.
22. Hass, Julius: Konservative und operative Orthopädie. 1 Aufl., S. 250 Abb., 217. Vienna, Julius Springer, 1934.
23. Jansen, Murk: The Large Brain, the Wide Pelvic Girdle and the Outstanding Number of Hip Anomalies in Man (Coxa Vara, Coxa Fracta, Coxa Plana, Coxa Valga, Slipping Epiphysis, Malum Coxae). J. Bone and Joint Surg., XI, 461, July 1929.
24. Kidner, F. C.: Causes and Treatment of Perthes' Disease. Am. J. Orthop. Surg., XIV, 339, June 1916.
25. Kirmisson, E.: Deux cas intéressants d'anomalies de développement du squelette. Rev. d'Orthop., X, 372, 1899.
26. Langenskiöld, F.: Demonstration eines mit Genu-varum-Bildung einhergehenden dunklen Leidens in der oberen Tibiaepiphyse, sowie über die Technik der bogenförmigen Osteotomie. Acta Chir. Scandinavica, LXIV, 193, 1929.
27. Legg, A. T.: An Obscure Affection of the Hip-Joint. Boston Med. and Surg. J., CLXII, 202, 1910.
Osteochondral Trophopathy of the Hip-Joint. Surg. Gynec. Obstet., XXII, 307, 1916.

28. Lewin, Philip: Epiphyses. Their Growth, Development, Injuries, and Diseases. Am. J. Dis. Child., XXXVII, 141, 1929.
29. Looser, E.: Spätrachitis. *In* Lehrbuch der Röntgendiagnostic. Von Schinz, Baensch, und Friedl. 2 Aufl., S. 212. Leipzig, Georg Thieme, 1928.
30. Lülsdorf, Fritz: Epiphysitis tibiae deformans. Ztschr. f. orthop. Chir., LIII, 64, 162, 1931.
31. Maselli, V.: Contributo allo studio dell'epifisite deformante tibiale giovanile in ginocchio valgo. Chir. d. Org. di Movimento, XVII, 267, 1932.
32. Mau, C.: Genu varum bedingt durch Tibiaepiphysendefekt bei kartilaginärer Exostose. Ztschr. f. orthop. Chir., XLIV, 383, 1923–1924.
33. McCurdy, S. L.: Some Rare Forms of Bone Lesions. Pittsburgh Med. J., XXV, 1922.
34. McWhorter, G. L.: Operation on the Neck of the Femur Following Acute Symptoms in a Case of Osteochondritis Deformans Juvenilis Coxae (Perthes' Disease). Surg. Gynec. Obstet., XXXVIII, 632, 1924.
35. Melchior, E.: Die Madelungsche Deformität des Handgelenks. Ergebn. d. Chir. u. Orthop., VI, 649, 1913.
36. Müller, E.: Ueber die Verbiegung des Schenkelhalses in Wachstumsalter; ein neues Krankheitsbild. Beitr. z. klin. Chir., IV, 137, 1888–1889.
37. Nilsonne, Harald: Genu varum mit eigentümlichen Epiphysenveränderungen. Acta Chir. Scandinavica, LXIV, 187, 1929.
38. Nussbaum, A.: Ueber Osteochondritis coxae juvenilis-Calvé-Legg-Perthes. Deutsche Med. Wchnschr., XLIX, 849, 1933.
39. Pels-Leusden, Friedrich: Klinische, pathologisch-anatomische und radiologische Studien über Exostosis cartilaginea multiplex. Deutsche Ztschr. f. Chir., LXXXVI, 434, 1907.
40. Perthes, G.: Ueber Osteochondritis deformans juvenilis. Arch. f. klin. Chir., CI, 779, 1913.
41. Phemister, D. B., Brunschwig, Alexander, and Day, Lois: Streptococcal Infections of the Epiphyses and Short Bones. Their Relation to Köhler's Disease of the Tarsal Navicular, Legg-Perthes' Disease and Kienböck's Disease of the Os Lunatum. J. Am. Med. Assn., XCV, 995, 1930.
42. Phemister, D. B.: Operative Arrestment of Longitudinal Growth of Bones in the Treatment of Deformities. J. Bone and Joint Surg., XV, 1, Jan. 1933.
43. Putti, V.: Osteotomia ed osteoclasia. Chir. d. Org. di Movimento, XVII, 1, 1932.
44. Rall, Gerhard: Genua vara wegen Deformierung der Tibiaepiphysen. Ztschr. f. orthop. Chir., LXI, 202, 1934.
45. Rall, Gerhard: Ungewöhnliche Deformität der Kniegelenke. (Osteochondropathia deformans juvenilis.) Ztschr. f. orthop. Chir., LII, 170, 1929.
46. Riedel, G.: Über Epiphysenlösung und vorzeitige Verknöcherung der Wachstumsfuge am unteren Femurende. Verhandl. d. Deutschen Orthop. Gesellsch. (20 Kongress, 1925), S. 280. Stuttgart, Ferdinand Enke, 1926. (Ztschr. f. orthop. Chir., XLVII, Beilageheft.)
47. Rocher, H. L., et Roudil, G.: Genu varum droit ostéogénique par hémiatrophie congénitale de l'épiphyse tibiale supérieure. Acta Chir. Scandinavica, LXVI, 275, 1930.
48. Ryffel, H.: Zur Thiemannschen Epiphysenerkrankung. Röntgenpraxis, V, 423, 1933.
49. Sloane, David, Sloane, M. F., and Gold, A. M.: Dyschondroplastic Bow Legs. J. Bone and Joint Surg., XVIII, 183, 1936.
50. Valentin, Bruno: Über eine eigenartige, bisher unbekannte Form multipler Epiphysenstörungen. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXIX, 120, 1922.
51. Van Gelderen, D. N.: Een Afwijking in de Bovenste Epiphyselijn van de Tibia (Deformation of Upper Epiphyses of Tibia). Nederlandsch Tijdschr. v. Geneesk., LXXVII, 1388, 1933.

A NEW OPERATION FOR HALLUX VALGUS AND HALLUX RIGIDUS

BY G. R. GIRDLESTONE, F.R.C.S., OXFORD, ENGLAND, AND H. J. SPOONER, M.D., REGINA, SASKATCHEWAN, CANADA

The purpose of this paper is to present a new operation for the relief of hallux valgus and hallux rigidus, and to report on the end results of thirty cases. This operation was devised and carried out in the Wingfield-Morris Orthopaedic Hospital. It was designed with the express purpose of avoiding the drawback which besets most, if not all, of the operations at present in vogue,—namely, the tendency to bring about or to increase splaying of the forefoot and metatarsalgia.

Hallux valgus is a twofold deformity,—valgus of the proximal phalanx of the great toe and varus of the first metatarsal. Normally the metatarsal heads are held in place indirectly by the muscles inserted into their phalangeal caps. (See Figure 1.) The forefoot is splayed, not through stretching of the adductor structures, but because the first metatarsal head escapes from the control exercised by the base of the proximal phalanx into which these muscles are inserted. The phalanx and sesamoids remain held by the adductors, while the first metatarsal head drifts away out of control. (See Figure 2.)

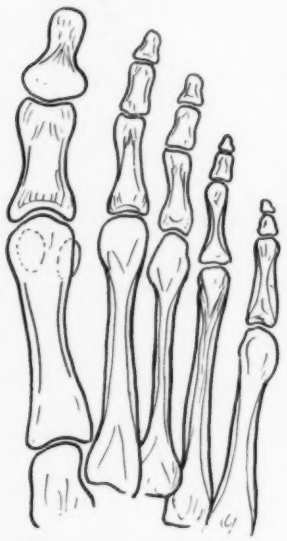

FIG. 1

The normal relationship between the metatarsals, the phalanx, and the sesamoids.

Hallux rigidus is a quite different disability, a disease rather than a deformity.

It is true that hallux valgus and hallux rigidus are sometimes coexistent, and that, therefore, an ideal operation should cure both. The operation which we advocate meets this test.

The most common operations have been:

1. Resection of the head of the metatarsal after the method of Mayo. This operation gives a fair cosmetic result, but, if enough bone is taken to free the joint, it interferes seriously with the important weight-bearing functions of the metatarsal head.

2. Hemiphalangectomy, subtotal, or total phalangectomy, combined with remodeling of the non-weight-bearing surface of the first metatarsal head. This operation can be relied on to produce a painless joint. However, because it removes entirely the insertion of the adductor structures, it has an unfavorable effect on the splaying of the forefoot, which in hallux valgus is the fundamental and the disabling part of the deformity.

In treating hallux rigidus it has been the practice, at the Wingfield-Morris Orthopaedic Hospital, for some eight or nine years previous to 1935, to do a partial phalangectomy, or, if the phalanx is short, a complete phalangectomy, with remodeling of the non-weight-bearing part of the head of the first metatarsal. One of us (G. R. G.) was introduced to this operation by Sir Robert Jones and Mr. T. P. McMurray, and the advisability of removing *at least* one-half of the phalanx was pointed out by the latter. We have found that occasionally we have removed too little of the phalanx, never too much.

FIG. 2

The typical alteration present in hallux valgus.

Many of the patients with well-developed hallux valgus complained also of metatarsalgia. In each case the patient had a wide, splayed forefoot with prominent metatarsal heads. In such a case a partial or total phalangectomy of course did nothing to relieve the metatarsalgia. On the other hand, in some cases in which the patients had not complained of metatarsalgia previous to operation, metatarsalgia developed after the operation. For these reasons, one of us (G.R.G.) has for a long time felt the need of an operation which would relieve metatarsalgia rather than tend to produce or to aggravate it by removing the point of insertion of the adductor structures.

If the anatomy of this part of the foot is considered, it is seen that the forefoot can carry the weight of the body comfortably provided that:

1. The metatarsal range is not splayed,—*i.e.*, that the ligaments and muscles holding them together are intact.
2. The normal metatarsophalangeal relationships are present.

The change in the metatarsophalangeal relationships associated with claw-toe or claw-foot is not dealt with in this paper, but we shall consider the metatarsals and the structures which hold them together,—the internal ligament and the adductor transversus hallucis. The intermetatarsal ligament is a narrow band running across and connecting the metatarsal heads. It blends with the plantar ligaments and is attached firmly to the bases of the first phalanges. The adductor transversus hallucis arises from the plantar metatarsophalangeal ligaments of the third, fourth, and fifth toes and from the transverse ligaments of the metatarsus; the adductor obliquus hallucis arises from the bases of the second, third, and fourth metatarsal bones and from the sheath of the tendon of the peroneus longus. These muscles are inserted via the fibular sesamoid and tendon into the fibular side of the base of the first phalanx of the great toe.

FIG. 4

Roentgenograms showing the loss of the normal relationship between the sesamoids and the first metatarsal, and splaying of the forefoot.

FIG. 3

It is interesting to note that the first metatarsal head is kept in its normal position indirectly and by means of its phalangeal cap exactly as are the other metatarsals. Therefore, if the base of the phalanx is removed, the attachments of the adductor structures are permanently lost, and the first metatarsal head drifts away.

Figures 3 and 4, which are typical of the common findings, show that, when the forefoot is splayed, the first metatarsal has lost its normal relation to the sesamoids. The ideal operation would utilize and intensify the action of the adductors rather than abolish the assistance which they were still able to give.

The following operative technique was devised by one of us (G.R.G.) in December 1934.

TECHNIQUE OF OPERATION

A straight incision is made along the tibial side of the foot, extending from just below the interphalangeal joint of the great toe to about one inch above the head of the first metatarsal. The skin is reflected; the

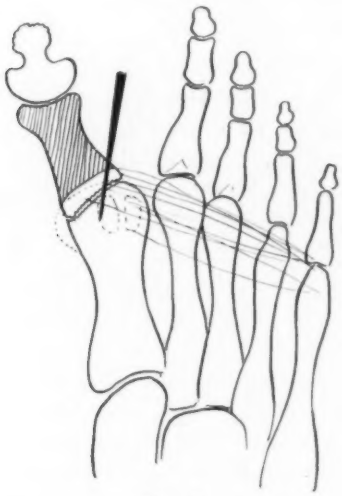

FIG. 5

Brad-awl in place, fixing the phalanx in the corrected position.

FIG. 6

Operation completed.

hemorrhage is controlled; and, with a second knife, the incision is continued down to but not through the periosteum. If a bursa is present, it is excised. Blunt dissectors are inserted extraperiosteally around the shaft of the proximal phalanx and, as these are separated, the shaft is exposed.

The metatarsophalangeal joint is opened by a transverse incision, leaving a sufficient margin of capsule attached to the tibial side of the first phalanx.

The interphalangeal joint is then opened and the whole distal end and

shaft of the phalanx are freed with a knife or gouge. The phalanx is grasped with a pair of lion forceps and the basal articular surface of the phalanx is denuded of cartilage and freshened.

The exostoses on the head of the first metatarsal are removed with a chisel and nibblers and the head is remodeled, without alteration of its weight-bearing surface. The head is cut away even more, in order to leave a small shelf on the tibial side, so that the phalangeal cap is fitted into the head at this point without a ridge.

A bandage is then tied firmly around the metatarsals, just above the heads, to bind them closely together.

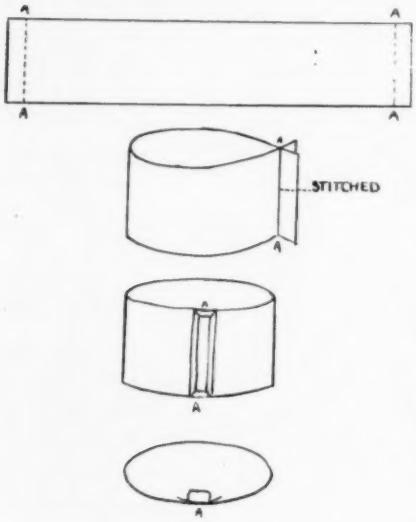

FIG. 7

The construction of a metatarsal strap. (The central pad should be broader and more oval than in the diagram.)

The distal end of the phalanx is again grasped in lion forceps and pulled as far as possible toward the tibial side of the head of the metatarsal, and a brad-awl is inserted through the base of the phalanx into the head of the metatarsal, in order to hold it firmly in position. (See Figure 5.)

The base of the phalanx is then sawed and nibbled through, leaving as thin a cap of bone as possible. The distal portion of the phalanx is removed. The cap of bone is rounded off and smoothed with nibblers and a file. Another brad-awl is introduced through the cap of bone into the head, and a beef-bone pin is driven through the hole. This fixes the cap of bone in place and the first brad-awl can be removed. (See Figure 6.)

The capsule is then sutured on the tibial side, giving the cap of bone additional support. The wound is closed in two layers with deep and skin sutures. Dressings are applied with the forefoot firmly bandaged to hold the metatarsals together.

The dressings are left undisturbed for ten days, and the patient is not permitted to bear weight. The stitches are then removed, and the arch is held by adhesive strapping with a small felt pad, approximately half an inch by two inches, placed on the plantar surface of the foot just above the second and third metatarsal heads. The patient can begin to walk on the foot in a fortnight. This strapping is kept on for approximately six weeks until roentgenograms show that there is union between the cap of bone and the metatarsal head.

The strapping is then removed and a metatarsal strap is applied for a varying period. (See Figure 7.) These metatarsal straps are made

as follows: The circumference of the foot is measured just above the metatarsal heads, — *e. g.*, eight and one-half inches. A piece of two-inch pink elastic webbing, nine and one-half inches long, is cut and the ends are turned back and sewed together, as indicated in Figure 7. A piece of Sarbo rubber, half an inch by two inches, is cut, and the edges are rounded off, covered with chamois, and sewed to the strapping at the joint. This may then be fitted on the forefoot, just above the metatarsal heads, with the pad in the midline of the plantar surface of the foot.

END RESULTS

The end results of thirty cases in which this operation was performed were compared with those obtained in twenty of the cases in which total or subtotal phalangectomy was done. The latter cases were picked at random and reviewed from the standpoint of metatarsalgia both before and after operation. The patients in this group ranged in age from fourteen to sixty-eight. Three had a definite history of metatarsalgia previous to operation. After operation ten complained of metatarsalgia and had a wide, splayed forefoot, although they obtained some relief from wearing a metatarsal strap continuously.

The thirty patients operated on with the new technique ranged in age from fourteen to sixty-three. Thirteen complained of metatarsalgia previous to operation. Only one of these complained of metatarsalgia following operation. The remainder did not complain of metatarsalgia before or after operation. Of the thirty, twenty had originally some splaying of the forefoot, with or without metatarsalgia, before operation. After operation only four had any marked degree of splaying.

The results of the operation described have proved most satisfactory and the authors are entirely convinced of the value of the method.

THE USE OF BONE CHIPS IN THE TREATMENT OF LOCALIZED OSTEITIS FIBROSA

BY ERNST FREUND, M.D., F.A.C.S., VENICE, FLORIDA

From the Department of Orthopaedic Surgery, State University of Iowa, Iowa City

In two other papers[1, 2] the problems of localized osteitis fibrosa and giant-cell tumors have been considered by the author from different angles. In regard to treatment, these papers dealt mainly with the evaluation of x-ray therapy and surgical interference. No definite conclusion could be reached concerning x-ray treatment, principally because of insufficient observations. It seemed, however, that the use of bone chips was of great importance in treating certain forms of localized osteitis fibrosa.

Two of the cases (Cases 1 and 5) which were used in the two previous papers are included in this study, with the addition of a few observations which, apart from the question of treatment, are also of considerable interest.

CASE 1. A boy, seventeen years of age, was seen complaining of pain and weakness of the left leg. He had had a severe trauma to the ankle ten years before admission. There had been some draining sinuses, and walking had been considerably impaired for about two years.

On admission, there was a bulbous enlargement of the lower portion of the leg, and the roentgenogram (Fig. 1-A) showed a smoothly outlined cyst of the size of a goose's egg in the lower metaphysis of the tibia.

The cyst was opened, curetted, and partially filled with bone chips removed from the same tibia. (See Figure 1-B.) The wound healed well, except for the upper corner, from which for some time there was a seropurulent discharge, and a few of the chips were expelled.

One and a half years after the operation the patient felt perfectly well. The lower end of the tibia had lost a great deal of its previous enlargement and the wound was healed. Roentgenographic examination (Fig. 1-C) showed good regeneration,—the cavity was filling in by coarse trabeculation and the size of the bone was definitely getting smaller.

In this case of a bone cyst in the lower metaphysis of the tibia, there was good healing after curettage and implantation of bone chips, despite mild postoperative infection with sequestration of a few of the bone chips.

CASE 2. A girl, five years of age, had fallen and had injured the right thigh three weeks before admission. Since that time she had refused to walk.

A roentgenogram (Fig. 2-A) revealed a cyst with smooth, thin, bony walls in the upper end of the right femur. The cyst was placed a little more toward the diaphysis than is usually the case, but without being a true diaphyseal cyst. There was no definite sign of fracture. A window, one inch long and two inches wide, was made in the atrophic cortex, through which the cyst was exposed and opened. The cavity was filled with clear serous fluid, and the wall was covered by a velvetlike fibrous membrane. After a thorough curettage, numerous bone chips, removed from the opposite tibia, were densely packed into the cavity. The limb was then immobilized in a hip spica.

The implanted bone chips took very nicely (Fig. 2-B), and the cavity became solidly filled with bone within the short time of three months. Roentgenograms taken one-half

FIG. 1-A

Case 1. A boy, seventeen years of age, with a bone cyst in the lower end of the tibia. Roentgenogram, April 20, 1933, before operation.

FIG. 1-B

Case 1. After curettage and implantation of bone chips, July 12, 1933.

FIG. 1-C

Case 1. About two years after operation, March 23, 1935, showing good regeneration.

year after the operation showed the defect filled very well with an irregular and dense bony tissue, which revealed signs of structural (functional) transformation.

This case of a simple bone cyst shows the excellent result of surgical treatment with numerous bone chips. It is very unlikely that simple conservative or x-ray treatment or mere curettage would have given such a quick and gratifying result.

CASE 3. A woman, forty-one years of age, was admitted with tenderness of the left foot of one year's duration. There was moderate swelling over the metatarsal heads, which was particularly painful.

The roentgenogram (Fig. 3-A) showed a cystic lesion in the diaphysis of the third metatarsal bone. The distal half was enlarged to about three times its normal size, and the cortex was thinned out and interrupted in a few places. The cystic area was multilocular and was surrounded by some osteosclerosis at the proximal end. The distal epiphysis was reached, but not involved.

The case presented some diagnostic difficulties. Benign enchondroma and localized osteitis fibrosa received the most consideration. The age was unusual for both affections, but the pure diaphyseal localization favored localized osteitis fibrosa despite the unusual localization in a metatarsal bone.

An exploratory operation was performed under tourniquet. The periosteal surface

FIG. 2-A

Case 2. A girl, five years of age, with a cystic lesion in the upper end of the femoral diaphysis. Roentgenogram, August 12, 1935, before operation.

FIG. 2-B

Case 2. Two months after curettage and implantation of bone chips, October 30, 1935.

FIG. 3-A

Case 3. A woman, forty-one years of age, with a multiloculated cystic lesion in the third metatarsal bone. Roentgenogram, July 13, 1935, before operation.

FIG. 3-B

Case 3. Six months after curettage and implantation of bone chips, January 27, 1936.

over the involved area was slightly irregular, but smooth. The periosteum could easily be stripped. The cortex over the dorsal side was thinned and reddish, due to hyperaemia of the underlying bone marrow, and it covered a system of small cysts which were filled with serous fluid and walled out by a velvetlike fibrous membrane. The cystic area was curetted until only the thin cortex preserved the continuity of the bone. The defect was densely filled with loose bone chips which had been removed from the lower end of the left tibia. The limb was then immobilized in a short cast.

The postoperative and pathological diagnoses were definitely localized osteitis fibrosa cystica; there were no signs of cartilaginous tumor formation.

All the bone chips took very nicely and the defect soon became filled by well-organized bony tissue. (See Figure 3-B.) The enlargement of the metatarsal bone has decreased, and a full restoration of contour and function can safely be expected.

In this unusual case of localized osteitis in a metatarsal bone, thorough curettage, followed by a dense filling of bone chips, secured an excellent result.

CASE 4. A boy, sixteen years of age, was seen, complaining of pain in the right ankle, which had followed participation in a football game one year previously. He could recall no special trauma. There was tenderness just anterior to the ankle joint toward the outer malleolus. Motion was painful only on forced dorsiflexion.

Roentgenograms revealed a cystic lesion of the size of a small walnut in the lateral portion of the body of the astragalus. The walls were smooth without any surrounding bone reaction.

An operation was performed by Dr. Arthur Steindler. Through the thinned-out cortical bone of the neck, a large cyst was opened, which contained a straw-colored fluid. The wall consisted in part of dense fibrous tissue, and in part of more reddish-gray granu-

lar material. After curettage, bone chips, removed from the tibia on the same side, were packed into the cavity and the leg was immobilized in a long cast.

The pathological examination revealed a considerable number of giant cells, as well as simple fibrous tissue. The diagnosis of a cystic giant-cell tumor was made.

The patient made a good recovery.

CASE 5. A girl, eighteen years of age, had sustained a lateral dislocation of the left knee three years before admission. She had had pain in the knee before the dislocation and roentgenograms had revealed "weakness" of bones. The dislocation had been reduced and the leg had been immobilized. Since that time the patient had had limitation of motion.

FIG. 4-A

Case 5. A girl, eighteen years of age, with a giant-cell tumor in the lower end of the femur. Roentgenogram, June 27, 1934, before operation.

FIG. 4-B

Case 5. After curettage and implantation of bone chips, December 27, 1934.

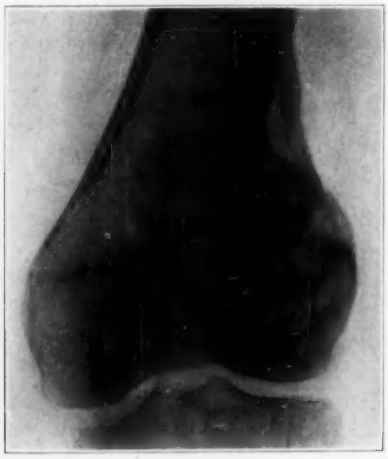

FIG. 4-C

Case 5. About one year after operation, July 29, 1935.

FIG. 4-D

Case 5. One and one-half years after operation, November 29, 1935.

Examination showed considerable valgus deformity of the knee. There was no swelling except for the lateral condyle of the femur, which was enlarged and could easily be palpated anteriorly. Motion was present from 180 degrees to 145 degrees.

Roentgenograms (Fig. 4-A) showed a large cystic lesion in the lateral condyle of the left femur, expanding the cortex on the lateral side without breaking through it. The walls of the cyst were not smooth.

Under tourniquet, a very careful curettage was done until healthy bony tissue was revealed. Many small bone chips were removed from the left tibia, and the huge defect was filled three-fourths full. The hip was immobilized in a spica.

The pathological report was: "Giant-cell tumor."

All the bone chips took very well (Fig. 4-B) and most of them became centers of quite active osteogenesis. The routine roentgenographic check-up (Figs. 4-C and 4-D) showed a gradually increasing homogeneization of the bony structure. There were no signs of tumor recurrence.

In this typical case of giant-cell tumor in the lateral condyle of the femur, treated by thorough curettage and bone chips, there was very good healing without signs of recurrence sixteen months following operation.

CASE 6. A woman, thirty-nine years of age, was admitted, complaining of pain in the right knee of six years' duration. She had been unable to walk on the leg. Shortly before admission, the leg had drawn up. There was a very marked enlargement of the region of the right knee (right knee, 45.5 centimeters; left knee, 39.0 centimeters) with increased local heat. Some tenderness was noted over the femoral condyles. Motion was present from 150 degrees to 90 degrees, with grating and pain.

Roentgenograms (Fig. 5-A) revealed a multilocular cystic tumor in the lower end of the femur, involving both condyles and extending up to the border of the middle and lower thirds, where signs of an old united transverse fracture were present. The clinical diagnosis was giant-cell tumor; the roentgenologist favored chondrosarcoma. To establish the diagnosis, an exploratory operation was indicated.

Under tourniquet, the lower end of the femur was exposed and a typical giant-cell tumor was found. A thorough curettage of the lower epiphysis of the femur was done. Both condyles were occupied by solid tumor tissue which extended down to the joint cartilage. A large number of bone chips were removed from both tibiae and were implanted into the huge cystic cavity which, however, could be filled only partially.

The postoperative period has been too short to warrant adequate judgment as to the results obtained from the operation. It seems that there is improvement, but the question of local recurrence remains open.

In this case of a very extensive benign giant-cell tumor, involving both condyles of the femur, the outcome is questionable. Such advanced cases of giant-cell tumor represent a very difficult problem for surgery. It is doubtful whether the procedure carried out in this case was adequate, despite the large number of implanted bone chips.

This type of operation was performed mainly because the patient insisted upon the preservation of the knee joint. It seems, however, that a radical resection of the lower end of the femur, followed by a plastic bone-graft operation, is a much wiser procedure in such cases. There are essentially two operative methods to be considered. The first, used by Albee, bridges the defect after resection of the lower end of the femur by several bone grafts taken from the tibia on the same side. One strong graft is firmly inserted into the freshened upper joint surface of the tibia. At least three other sliver grafts are placed around the main graft, so as

FIG. 5-A

Case 6. A woman, thirty-nine years of age, with a giant-cell tumor in the lower end of the femur. Anteroposterior roentgenogram, September 11, 1935, before operation.

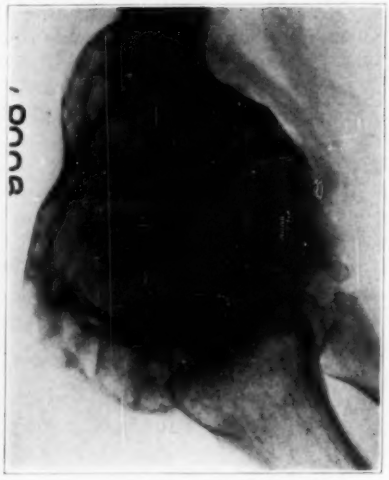

FIG. 5-B

Case 6. Lateral roentgenogram, before operation.

FIG. 5-C

Case 6. Anteroposterior roentgenogram taken through plaster-of-Paris cast after radical curettage and implantation of bone chips, September 24, 1935.

FIG. 5-D

Case 6. Anteroposterior roentgenogram, six months after operation, March 11, 1936.

to form a pyramidal structure. This is further reenforced at the site of the knee joint by the patella, which has been split in two at the beginning of the operation. This is an excellent method, as demonstrated by some of Dr. Albee's cases.

The other method, described by Juvara, uses the front half of the tibia, which is turned to 180 degrees, so as to bring its distal end in contact with the distal end of the femur. Its proximal portion, the head of the tibia, remains in contact with the corresponding part of the posterior half.

In both methods, the knee joint has to be sacrificed. However, the extremity can be preserved in its normal length, and for this reason the method is preferable to amputation. The only inconvenience is the protracted period of immobilization. As a rule, consolidation, sufficient to permit free weight-bearing, takes at least eighteen months.

CASE 7. A man, twenty-five years of age, had complained of pain in the left hip for four months. The affection had started suddenly with severe pain over the greater trochanter; the pain had gradually increased and the leg had grown weaker. The patient appeared in excellent general health. Muscle spasm around the left hip and exquisite tenderness on percussion over the greater trochanter and heel were present. Marked atrophy of the left lower extremity was noted.

Roentgenographic examination (Fig. 6-A) showed a purely osteoclastic lesion in the upper end of the femur without sharp outlines and without any form of demarcation.

The roentgenographic appearance was unusual, but it seemed to indicate the presence of a giant-cell tumor. The age of the patient and his general good health, as well as the epiphyseal involvement, favored this diagnosis. To arrive at a certainty, an exploratory operation was indicated.

At operation, the joint capsule was found to be thickened by oedema. The joint cartilage of the head of the femur appeared thin and bluish and could easily be pressed down because of lack of supporting bony tissue. The neck and a large part of the head were occupied by a large cyst, surrounded only by a paper-thin shell of bone. The latter was perforated in several places, but there was no invasion of the surrounding soft tissues by tumor. The cavity extended into the head of the femur as far as the joint cartilage, and further down into the trochanteric region and into the diaphysis. The walls of the cyst were formed by a thin layer of granular tumor tissue which was curetted out. The amount of solid tumor tissue was slight, the lesion being almost purely cystic. Frozen sections confirmed the diagnosis of giant-cell tumor. Therefore, a great many bone chips were removed from the diaphysis and upper metaphysis of the left tibia. Further bony material was obtained from the wing of the ilium. All the chips were implanted into the huge bone defect, filling it quite adequately. (See Figure 6-B.)

The patient made an uneventful postoperative recovery and was discharged. He returned after two months in a markedly run-down condition. He had felt very poorly at home and had had pain in the hip region, sometimes of a sharp, shooting character. The hip region was swollen, showed fluctuation, and was tender. The patient ran a subfebrile temperature. The lungs were clear on clinical and roentgenographic examination.

Roentgenographic examination (Fig. 6-C) revealed definite progress of the osteoclastic lesion, which now had fully destroyed the greater trochanter and the head of the femur and had also extended further down into the diaphysis. Because of the histological diagnosis, the lesion was still considered as a giant-cell tumor of very pronounced activity. It was thought best to resect the upper end of the femur and to replace it by the upper half of the fibula.

At operation, a large amount of brown bloody fluid, containing a few flakes of necrotic tissue or clotted fibrin, escaped. The upper third of the femur was practically gone; there remained only a few eroded portions of bony tissue, representing in part the atrophic lower cortex of the femoral neck, and in greater part the transplanted bone chips which formed a rather dense mass of bone. The large cavity which contained the

bloody fluid was walled off by a very irregular tumor tissue of brownish-red stain with quite extensive necrosis. All the surrounding soft tissues were invaded, and there was extension into the subcutaneous fat tissue. In view of these facts, there could not be any doubt that a highly malignant tumor had destroyed the upper third of the femur

FIG. 6-A

Case 7. A man, twenty-five years of age, with a giant-cell sarcoma of the upper end of the femur. Roentgenogram, July 10, 1935, before operation.

FIG. 6-B

Case 7. After curettage and implantation of bone chips, July 20, 1935.

FIG. 6-C

Case 7. Two months after operation, September 12, 1935. Note the rapid progress of bone destruction.

FIG. 6-D

Case 7. Three and one-half months after operation, October 28, 1935.

and was in full and irresistible expansion toward the soft tissues. The tumor was rapidly growing, but also rapidly disintegrating, thus leading to the huge cystic cavity. At the operating table the diagnosis had to be changed from giant-cell tumor to giant-cell sarcoma.

The patient's condition improved slightly after the drainage of the cavity. He received x-ray treatment and was discharged. Metastases to the lungs developed, and the patient died a short time afterward.

In this case (giant-cell sarcoma of the femur), the implanted bone chips resisted fairly well the rapid tumor growth with its osteoclastic activity; they remained balled together in the middle of the huge cavity, whereas the bony tissue of the femur yielded readily. The case appeared to be unusual from the roentgenographic view-point. Although at the time of the first operation the pure osteolytic lesion, with very little solid tumor tissue and a clinical history of relatively short duration, did not seem to be a simple and benign form of giant-cell tumor of bone, the histological picture of the tissue removed at that time appeared to be quite typical of giant-cell tumor. A large number of slides were examined and rechecked later. After the second operation, the histological picture was quite different. There was marked anaplasia of tumor cells with mitotic figures and very irregular giant cells, which looked like a syncytium rather than individual cells. The tumor showed definite affinity to bony tissue. When this tissue was destroyed, the tumor became necrotic and liquefied.

From the difference in the histological picture, one would be inclined to believe that a primarily benign giant-cell tumor had been stirred up by the operation and had undergone malignant changes. The author feels, however, that, despite the difference in the histological picture, this lesion started as a malignant tumor, and he does not think that the degree of malignancy was aggravated by the surgical intervention. However, one has to admit that the latter certainly did not improve the condition. The question arises: What should have been done instead? The lesion was so extensive, even at the time of the first operation, that it seems rather doubtful whether the enucleation in the hip joint would have saved the life of the patient. The only possibility appears to be the interilio-abdominal amputation. This operation was considered when the femur was explored for the second time, but was not carried out because of the patient's poor general condition.

SUMMARY

The use of bone chips is an excellent method of treating localized cystic osteitis fibrosa. It certainly is superior to simple scraping and the use of caustic substances. The cavity can be filled much easier with chips than with solid cortical bone grafts, and it seems also that the power of osteogenesis is greater with the use of chips. Giant-cell tumors are not so susceptible to this form of treatment, especially if they are in the more advanced stage and if too great a defect results after the curettage

of the tumor tissue. Nevertheless, the author obtained a very good result in one case in which the entire lateral condyle was involved.

Care should be taken to fill the defect with the chips as completely as possible. If necessary, both tibiae may be used as donors. In too advanced cases or in recurrent cases of giant-cell tumor, resection with heavy, bridging, tibial grafts is preferable to the less radical procedures, such as curettage and the use of bone chips, and to the more radical ones, such as amputation and exarticulation.

1. Freund, Ernst, and Meffert, C. B.: On the Different Forms of Non-Generalized Fibrous Osteodystrophy. Surg. Gynec. Obstet., LXII, 541, 1936.
2. Freund, Ernst: Giant-Cell Tumors. To be published.

HISTORY OF FRACTURE TREATMENT UP TO THE SIXTEENTH CENTURY *

BY WILLIAM ARTHUR CLARK, M.D., F.A.C.S., PASADENA, CALIFORNIA

Through all the changes in medical and surgical knowledge and in technique in the history of medicine, there are some subjects, such as obstetrics and fractures, in which, because of their nature, there has been very little change. The broken leg and the blessed event are traditionally linked with the doctor in caricature and story. It is, therefore, easier to trace the history of fracture treatment back through many centuries than it is to find what was known or done a hundred years ago about some of the "modern" diseases.

Because the mechanical factors in fractures were the same in the first century as they are in the twentieth century, the methods of treatment in ancient times are found to be similar, not only in principle but in practice, to those of our own day. One is astonished to find in medieval text-books descriptions and illustrations of instruments which, if nickel-plated, might be mistaken for equipment in our modern hospitals. It might be supposed that extension methods by windlasses, levers, ratchets, and pulleys may have had their inception in the torture chambers of the Spanish Inquisition, but, as a matter of fact, they date back to Hippocrates. As to splints, the simple and primitive expedient of holding together the parts of a broken staff by binding them to a sound staff would naturally occur to any people of intelligence and its application to a broken bone would not be very hard to imagine.

Prehistoric man must have had his troubles with broken bones. According to Sudhoff, the bones of Neolithic man show traces of attempts at corrections of deformities. Apparently enough specimens of fractured bones from that age have been found to justify statistical statements. Karl Jaeger found 53.8 per cent. of good unions as against 46.2 per cent. of bad unions in prehistoric fractures, a noteworthy achievement on the part of the Neolithic man.

EGYPTIAN METHODS

Recorded descriptions of the methods of Egyptian physicians are very scanty. Our knowledge of those days comes more from the finding of remains of their handiwork than from their writings.

In the Edwin Smith Surgical Papyrus are found sketchy references to fractures of the clavicle, the humerus, and the cervical spine. "If thou examinest a man having a break in his collar-bone, . . . thou shouldst place him prostrate on his back, with something folded between his two shoulder-blades; thou shouldst spread out with his two shoulders

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 19, 1926.

in order to stretch apart his collar-bone until that break falls into its place. Thou shouldst make for him two splints of linen, (and) thou shouldst apply one of them both on the inside of his upper arm and the other on the under side of his upper arm. Thou shouldst bind it with *ymrw*,* (and)treat it afterward [with] honey every day, until he recovers." Treatment for the humerus is described, but the text is practically the same as for fracture of the clavicle.

An impacted fracture of a cervical vertebra, caused by a fall in which the patient landed on his head, is mentioned, but there is no reference to treatment. It is stated, however, that the accident was fatal.

Archeological excavations have yielded a great number of specimens of fractures, some healed and others in splints not yet united. Fractures of the forearm bones are most numerous, supposedly because the arm was used in defense against blows with the "naboot". In excavating in the Nubian desert, a graveyard was found, which contained remains of bodies with fractured limbs that had been set with bark splints. One specimen was a femur, which was held in position by a splint and bandage and was tied with true reef-knots. The wrappings of palm-fiber cloth "were set just as a good surgeon would set them in these days so as to use the full strength of the fabric".[7] From the Nubian excavations also came several specimens of forearm fractures which are now in the museum of the Royal College of Surgeons in London. One of these, examined by the author, is a model of neat splinting with wood from the stems of palm leaves, the padding being of coarsely woven cloth such as we today would call home-spun. On turning back the posterior splint, the fracture of both bones is visible, the soft tissues having almost vanished. There is good approximation, but no union. Mr. Cave of the Museum says: "The splints are applied without any attempts at control of the fragments. Similar splints were employed in the repair of royal (and other) mummies damaged by the tomb-plunderers of antiquity; and since, in Egyptian eyes, the mummy was ceremonially alive, this office exactly corresponded to the treatment of a living patient. Splints of a similar nature are still employed in the Sudan and Abyssinia, and in Borneo and elsewhere in the Malay Archipelago."

HIPPOCRATES (460–377 B.C.)

In the voluminous writings of this Greek scholar, fractures and their treatment are given generous space. Reflecting the high plane of civilization and culture of his time, the chapters devoted to this subject would be a credit to a modern system of surgery. He was explicit in the details of his descriptions of methods. For example, let us quote his directions for treatment of a fracture of the humerus: ". . . having got a piece of wood a cubit or somewhat less in length, like the handles of spades, suspend it by means of a chain fastened to its extremities at both ends; and having seated the man on some high object, the arm is to be brought over, so that

* A metal which cannot be identified.

the armpit may rest on the piece of wood, and the man can scarcely touch the seat, being almost suspended; then having brought another seat, and placed one or more leather pillows under the arm, so as to keep it a moderate height while it is bent at a right angle, the best plan is to put round the arm a broad and soft skin, or broad shawl, and to hang some great weight to it, so as to produce moderate extension; or otherwise, while the arm is in the position I have described, a strong man is to take hold of it at the elbow and pull it downward. But the physician, standing erect, must perform the proper manipulation, having the one foot on some pretty high object, and adjusting the bone with the palms of his hands; and it will readily be adjusted, for the extension is good if properly applied."

He describes mechanical extension for fractures of the thigh or leg: ". . . having fixed in the ground either the nave of a wheel, or any such object, something soft is to be bound round the foot, and then some broad thongs of ox-skin being brought round it, the heads of the thongs are to be fastened to a pestle or any other piece of wood, the end of which is to be inserted into the nave, and it, the pestle, is to be pulled away, while other persons make counterextension by grasping the shoulders and the ham." For counterextension: ". . . fasten deeply in the ground a round, smooth piece of wood, and place the upper extremity of the piece of wood at the perineum, so that it may prevent the body from yielding. . . ." He used a fracture table called the Scamnum which he describes as follows: "But the best thing is, for any physician who practices in a large city, to have prepared a proper wooden machine, with all the mechanical powers . . . either for making extension, or acting as a lever." He recognized the difficulties involved in fracture of the femur and the possibilities of deformity: ". . . for it is a great disgrace and an injury to exhibit a shortened thigh. For the arm, when shortened, might be concealed, and the mistake would not be great; but a shortened thigh-bone would exhibit the man maimed."

In compound fractures he advised against the then common practice of binding the limb on either side and leaving the wound out, because the wound then becomes discolored and gets into a throbbing and inflamed condition. He advised applying to the wound "a cerate mixed with pitch", over which is bound "a thin folded compress"; then "the parts around are to be anointed with white cerate". Splints should *not* be put on, but the bandages should be sufficient to give some fixation, and should be adjusted so that the pus would discharge freely. In summer the bandages were frequently dampened with wine and in winter with greasy wool, moistened with oil and wine.

Permanent fixed extension was obtained in leg fractures by the ingenious use of the springing force of heavy elastic twigs from the cornel tree. Thickly padded rings were put around the leg,—one just below the knee, the other at the ankle. Four of these wood twigs or rods were then placed on the four sides of the leg. They were cut a little longer than the distance between the padded rings and forced in between the

rings by bending. The ends of the rods then impinged against the rings and exerted extension by their tendency to spring into a straight line.

Bone skids, such as we use in open reduction, were employed by Hippocrates for reducing protruding bones in compound fractures. He had several different sizes to fit various bones and used them as levers in conjunction with extension. This procedure had to be done before the third or fourth day. "For if the limb is disturbed on these days, and yet the fractured bones not reduced, inflammation will be excited, and this no less if they are reduced; for convulsions are more apt to occur if reduction take place, than if the attempt should fail."

Compound fractures of the femur and humerus were regarded as often fatal, whether or not they were reduced. The dangers which today take the form of malpractice suits are suggested when Hippocrates says: "But one should try to escape from such cases, provided one can do so honorably, for the hopes of recovery are small, and the dangers many; and if the physician do not reduce the fractured bones he will be looked upon as unskillful, while by reducing them he will bring the patient nearer to death than to recovery." He advised treating fractures of the jaw by binding the teeth together with gold or linen thread. He described a succussion method for reducing fractures of the spine. The patient was bound to a ladder, which was then raised perpendicularly with ropes and pulleys and let down suddenly, so that the jolting might reduce the deformity. However, Hippocrates did not practise this method himself. He described the appearance of a heel after the patient had fallen from a height and had landed on the feet, but he probably did not recognize a fracture of the os calcis.

ROME

The dawn of the Christian Era did not bring with it any appreciable activity in development of the medical arts. Rome borrowed her physicians from Greece. Pliny said: "For it is a well-known fact that those physicians who, without being able to speak Greek, attempted to build up a practice in Rome, failed to gain the confidence of their patients, even of those who were not at all familiar with that language." [7] Medical and surgical literature from the Roman Empire is sadly lacking. In the Byzantine period, about the tenth century, the methods of Hippocrates, with modifications and refinements, are seen in the work of Nicetas whose writings are accompanied by drawings, showing methods of permanent extension and reduction by windlasses and pulleys.[4]

ARABIAN SCHOOL

From the ninth to the twelfth centuries a bright spot appears in the form of writings by Rhazes (850–932), Avicenna (980–1037), Albucasis (1013–1106), Avenzoar (1113–1162), and others in Arabia. Avicenna and Albucasis are recorded as being in favor of suturing the flesh wound in a compound fracture. Avicenna practised open reduction. For malunion he advised that the flesh be cut and the callus removed by rubbing

it away, then the bone could be restored to a good position. Causes of nonunion were advanced by Avicenna as follows: " . . . multiple embrocations with warm water; and frequent changing and haste and moving the organ; when there is little viscous blood or too great stricture, which prevents the limb from being nourished; or the presence of pieces of bone." [13]

Albucasis used coaptation splints and is given credit for this method by Guy de Chauliac. He held that the bone of the spine could be fractured, but that seems to have been contrary to the general opinion that spinal deformities came only from attrition. He stated that if a patient lost control of the bladder and bowels, following a back injury, the condition was mortal and that it was useless to try to cure it.

GUY DE CHAULIAC (1300–1370)

This French surgeon (also called Guido de Cauliaco) was an authority in his time. He is much quoted by writers for three centuries following his death, and is sometimes referred to as the greatest of medieval surgeons. An old English translation [12] of his "The Questyonary of Surgeans" is written in the form of questions and answers. In reply to the question—"Whether the scyence of nathomye be necessarye and nedefull to the cyrurgen or not?"—he replied: "The same manner that the blinde man worketh in hewynge of a log, so doth a cyrurgen that knoweth not the nathomye."

He emphasized the use of ointments and salves in the treatment of fractures; two pages in this edition are filled with formulae for various mixtures to be applied to the limb. In fact, he is considered by some historians [11] to have been reactionary in this respect and to have delayed progress in surgery by endorsing the doctrine of interference and meddling instead of trusting in the power of nature to heal wounds. Perhaps it was this influence which inspired Paré to say (200 years later) "I dress it, but God cures it."

In a modern translation [13] of Guy de Chauliac's book on fractures, methods of reduction and retention are given in detail. For compound fractures he advised the extraction of "foreign substances such as arrows or pieces of bone", then "the separated parts of the bone should be brought together and the flesh wound deeply sutured and closed firmly". The limb was then bandaged "in such a way that the wound can be attended to . . . without undoing all the bandages and supports". Even then, as today, there was a difference of opinion regarding complete closure of wounds in compound fractures. Guy de Chauliac said: "And how will the bone be repaired unless by the intervening flesh? . . . I believe that nothing nourishes with true nutrition which does not come from the stomach to the liver and to the veins scattered throughout the flesh, hence to the bones. . . ." He described coaptation splints made of willow, sword-handle wood, horn, iron, or leather, but said that they should neither touch nor injure the joint. They should surround the limb about one finger's breadth apart and then be covered with cloth and moistened

A table conteynyng the differences of fractured bones

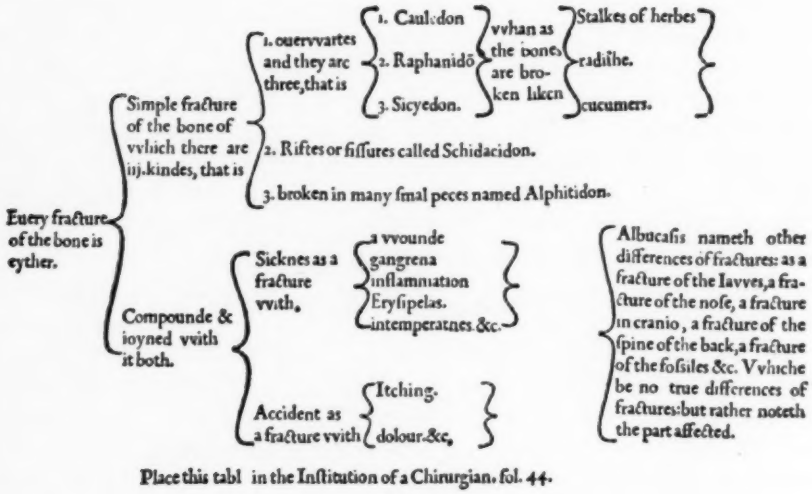
Euery fracture of the bone is eyther.
Simple fracture of the bone of vvhich there are iij. kindes, that is
1. ouervvartes and they are three, that is
1. Caulædon
2. Raphanidō
3. Sicyedon.
vvhan as the bones are broken liken
Stalkes of herbes
radiſhe.
cucumers.
2. Riftes or fiſſures called Schidacidon.
3. broken in many ſmal peces named Alphitidon.
Compounde & ioyned vvith it both.
Sicknes as a fracture vvith,
a vvounde
gangrena
inflammation
Eryſipelas.
intemperatnes &c.
Accident as a fracture vvith
Itching.
dolour &c,
Albucaſis nameth other differences of fractures: as a fracture of the Iavves, a fracture of the noſe, a fracture in cranio, a fracture of the ſpine of the back, a fracture of the foſsiles &c. Vvhiche be no true differences of fractures: but rather noteth the part affected.
Place this tabl in the Inſtitution of a Chirurgian. fol. 44.

FIG. 1

A sixteenth-century classification of fractures from "Certaine workes of Chirurgie", by Thomas Gale, 1563. (From the rare-book collection, The Huntington Library, San Marino, California.)

with egg white. This egg-white method is mentioned in many surgical writings of medieval times. It is probable that it served to stiffen the bandages as does plaster-of-Paris. A method of tightening and holding the splints was to "have some cannulae tied with a cord, . . . and let the splints be bound with the cord so that by twisting the cannulae they may be sufficiently tightened; then a little rod is passed through the cannulae in order that they do not lose their revolution and tightness". He advised "a cradle or suspensory in which the limb will be firmly and evenly placed" and "a mattress bed on which the patient sleeps, . . . perforated so that he may go to stool" and a "cord hanging over the bed, or some other thing for him to catch and help himself when he wishes to go to stool or straighten or turn himself". Splints were only to "sustain" during the first seven days until swelling subsided, after which they were to be placed in such a way as to actually restrain the bones. A diet of rice, wheat cooked in water, boiled feet, viscera, and heads of animals, and strong astringent wine was prescribed to engender callus. "If the callus is small let nourishment be drawn to the place by frictions and embrocations and pitch plasters and loose ligature."

He probably did open reductions after the method of Avicenna, and he often found a weight and pulley useful. His advice concerning fracture of the jaw and of the clavicle was the same as that of Hippocrates. Depressed rib or clavicle fractures were pulled out either by suction with some glutinous substance or with the palm of the hand, or by a hook. Fractures of the humerus were reduced by manual extension; the frag-

ments were immobilized with five or six splints; and the arm was put in a sling. Union was timed at forty days. Regarding the hip, he stated that: "The bone of the hip is scarcely often broken, but it is sometimes split, and its edges are crushed. Sometimes it is pushed into the abdomen, . . . and the fracture is very difficult to reduce." For the thigh, six or seven splints and strong extension were used. He did not approve of a method described by Albucasis in which the leg was bound to the thigh so that the heel touched the buttock. "With regard to myself, the thigh being bound with long splints. . . . I attach to the foot a leaden weight, passing the cord over a little pulley so that it will keep the leg in its proper length. . . ." Union was timed at fifty days. Leg fractures were treated with the same contrivance as for the thigh. He did not recognize fracture of the patella or of the os calcis, but stated that the patella was frequently distorted and should be restored to its shape and held with a round wooden splint. "The heel bone does not break, inasmuch as it is a hard bone protected or covered with ligaments."

In short, we find that Guy de Chauliac used weight traction, suspension, an overhead monkey pole, massage (friction and embrocation) and damming for delayed union, coaptation splints, débridement, and open reduction.

FIG. 2

Anterior and posterior views of fracture of tibia and fibula from an ancient Indian skeleton found in a grave, five feet deep, under a heavy slab of limestone. The skeleton lay face down with arms and legs folded under the body. (From the Southwest Museum, California.)

and ſaue his helth/and alſo ſa moze ſurety Romanus layeth ỳ pacyent on a ſmall bed/ vnder the whiche bed is an hole thzugh the whiche he may do his water/ and easment without lyftynge of hym ſelfe/ and he muſt be bounde to. iij. oz. iiij. places of ỳ bedſtede and ỳ hole foote muſt be bounde to the ſtock that ỳ pacyent may not dzawe it vp to hym and Guydo bynderh hym with longe ſplentes/and layeth on hym a wayght & byndeth to his foote a plomet of leade/and as al this is ozderned and done/ ſo ſhall he holde and rule as I haue ſayd in ỹ. lix. chappter with blodlettynge/ dzaught gopnge/ and with eatynge and dzynkyng/ ye ſhall dzeſſe hym dylygently. iiij. b. oz. vi. dayes togyder/ wt out he be very ſyke/ and at euery dreſſynge/ ye ſhall loke well on the legge how it is diſpoſed/ and yf it be not ſet vpzyght/ take hed & gyue hym his ryght fozme/ therfo;e take ye hede in ỹ fyrſt begynnynge/ foz yf it ſholde ſtonde longe/ it ware hatde to make it vp ryght/ is ther one wounde grete/ then ſe yf ther be ony bone depred that take awaye/ and ſow the wounde/ and on ỹ ſame ſtrawe that powder that belongyt therto/ as in the xiij chaptre is ſayd/ and as ye the membze hathe ſet vp ryght well togyder/ than take wode ſplentes after the degre of the woũde & that the ſplentes towche not the woũde/ whan ye bynde the legge/ and alſo that ye may euery day ſe to the wounde/ and on the woũde lay the afozſayd powder ỹ be layde vpon the ſeme and vpon that powder lay ỹ mundificatiuum plaſter.

¶ A Plaſter.

Take roſe hony ſtreynyd. xij. oũces. Barly meele/ Wylſtuf meele/ oz other lyke. xij. ounces/ of this powder that lyeth on the ſeme. take. ij. ounces. and medle this togyder and as the wounde with this plaſter is cleanſed/ than hele it vp the grene woundyd plaſter/ and with powder of Cypzeſſe nottes/ Mumie/ Frankēſence/ Gall apple/ of eche vi. ounces. and on the ſame lay the powder of Dzagons blood/ Dzagātum/ Gomy of Arabice/ of eche lyke moche/ and all this mydle togyder.

¶ Of the bzekyng of the knee ſhyne oz whozle bone. Ca. lxxij.

When the knee ſhyne is bzoken/ then ſet it agayne vp ryght with your hande in the beſt maner as it can be than lay ther vp ỹ plaſter made of Barly meele/ oz Beene meele/ and Dzagons bloode &c. & ye ſhall not lay ther on the clothe depte in to ſe oyle/ and as the plaſter is layed theron/ than ſtryke ther about the Bekenſiuũ/ and therafter lay vpon it Plumacioles of tow/ and therafter ſplentes/ and therouer bynde it well with ỹ bande and ſow the bande wt whyt threed/ and let hym bloode on ỹ hande/ betwene the lytell fynger and the golde fynger/ & rule hym in gopnge to dzaught/ and wt meete and dzynke/ as is afozſayd.

¶ An inſtrument to make a croked knee ryght.

Fig. 3

A page from "The noble experyence of the vertuous handy warke of surgeri", by Jherome of Bruynswyke, 1525.[6] An old English translation of a German book. (From the rare-book room, The Huntington Library.)

AMBROISE PARÉ (1510–1590)

Paré quoted Hippocrates frequently; some paragraphs were almost literal translations, as, for example, the one on fracture of the femur in which he described extension methods and gave details regarding bandaging. He advised reduction of fracture of the coccyx by internal and external manipulation followed by recumbency. For compound fractures he used splints of shaped metal with notches cut out, so that the wound would be accessible without removing the splint.

In one instance he was called to see a woman with an injury to her hip and, on finding the leg short and the trochanter prominent, he thought it

was a dislocation. He pulled and manipulated the leg until it was the same length as the other. Two days later he revisited the patient and found the leg again short and turned out. On removing the bandages, crepitation was felt. He then reduced the bone and applied splints and bandages "*en croix S. André*" (spica). The patient was confined to the bed with an arc at the foot to keep the bed clothes from pressing on the toes, and a cord was suspended from a beam over the middle of the bed so that she could raise herself with her arms. He described fracture of the patella (a fracture not mentioned by Hippocrates or by Galen) and reduced the fragments by extending the leg. The leg was kept still as though it were broken until the callus was hard. He stated that he had never seen a patient who did not limp after such a fracture because the healed fragments impaired extension of the knee and made it difficult to go upstairs. Union required a long time in bed,—forty days or more.

HIERONYMUS BRUNSCHWIG (1450–1533)

The first important book on surgery to appear in England was a translation [6] of Brunschwig's work which was published in Strasbourg in 1497. It is one of several books on surgery of the fifteenth century, printed in old English type, with quaint spelling and construction, which are to be found at the rare-book room of the Huntington Library, San Marino, California. Brunschwig was a German surgeon of outstanding ability. He quoted Guido de Cauliaco (Guy de Chauliac), Avicenna, and Albucasis frequently in the part of the book which deals with fractures. He seemed to have been a disciple of Guido de Cauliaco, as far as the use of ointments and other applications was concerned. "Yf the flesshe

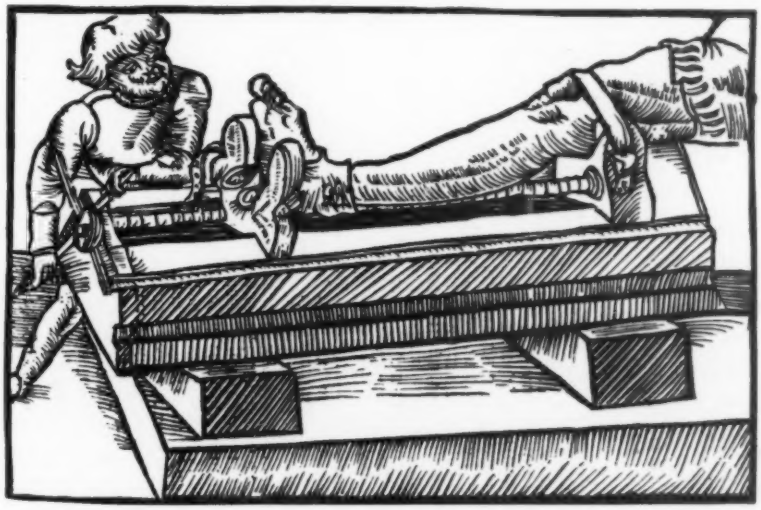

FIG. 4

An instrument to make a crooked knee straight, referred to in the text reproduced in Fig. 3.

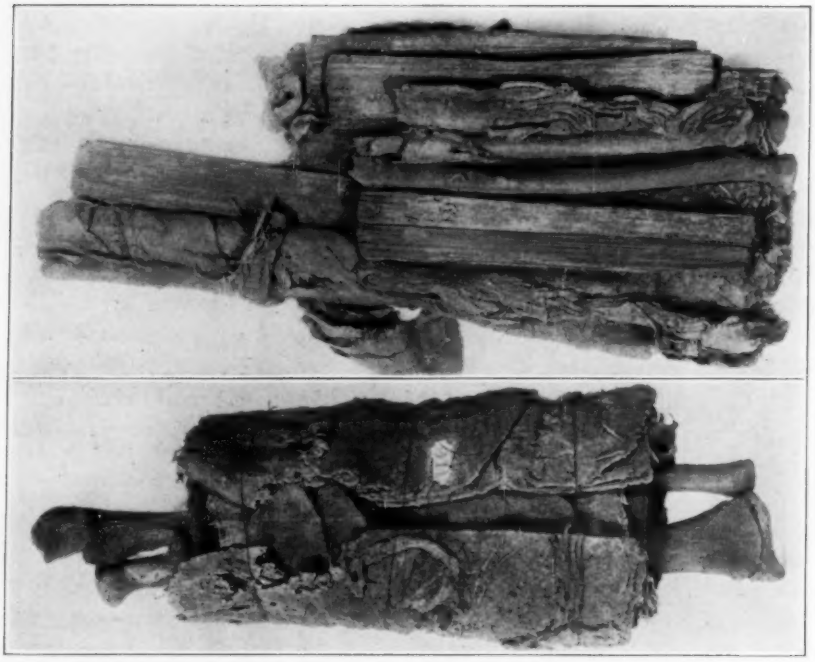

FIG. 5

Two specimens of fracture of the forearm from Egyptian mummies. From the Nubian Collection, Royal College of Surgeons, London. No. 115 (above) shows the unwrapped arm with splints made from the midrib of the palm; No. 116 (below), the outer wrappings of the splinted arm. Both specimens belong to the Pyramid Age of the Old Kingdom, Fourth Dynasty, about 2500 B.C.

be brused with the fracture of the bone then shall the bone be bounde with oyle of roses and shall lay on the powder of myrtylle beryes and over the oyle and powder ye shall lay a cloth depte in the white of egges and oyle of roses and bynde it softely." An uneven break in a bone he called "frustration" and a longitudinal fracture was called "apertura". Splints were made of box or hard wood, or of horn. They must be thicker in the middle than at the end and must not press on the joints. Mechanical apparatus is suggested where he stated that in reduction one pulled down and another up, "but it were very good to have a vyce made therefore tyll the membre be bounde". He advised an abundance of meat in the diet because "theron cometh that conglutinatinum [callus?] that is helynge".

Apparently experimental surgery was done in those days. In order to prove the efficacy of a powder made of "bolarmen, ambra or walderote and small barlye mele" mixed together, a dog's leg was broken and this powder, mixed with white of egg, was laid on the dog's leg which was then splinted. "As ye viij days were past then take the splentes of and the dogges legge was hole."

In compound fractures he advised taking out small pieces of bone. The pain was then taken away by salving with "oyle of roses".

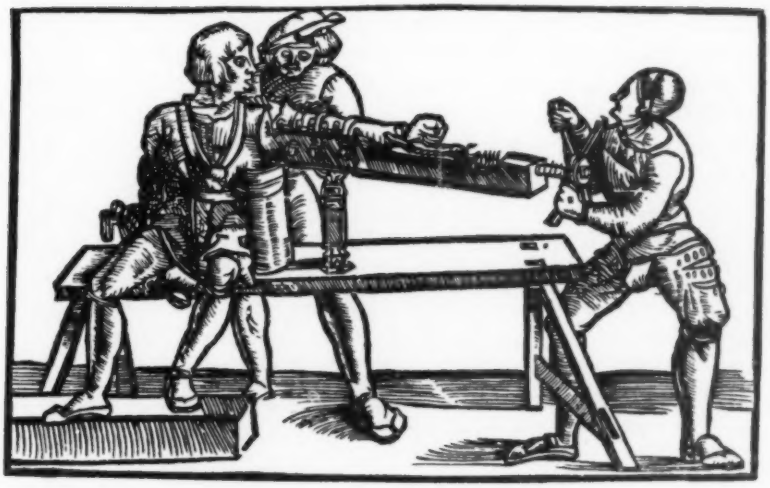

FIG. 6

Mechanical extension of the humerus. From Bruynswyke, 1525.[6] This resembles the glossocomium of Hippocrates. (The Huntington Library.)

Directions were given for reducing a fractured jaw by inserting a finger of one hand in the mouth and by pressing the other hand on the cheek. The teeth were to be braided together with silk thread or fine copper wire to maintain the fragments in approximation. He thought that fracture of the spine seldom occurred, but he recognized paralysis from back injuries, and localized the lesion in a general way by observing what limbs were paralyzed. Agreeing with Albucasis, he said that one should not attempt to cure a patient who had lost control of the bladder

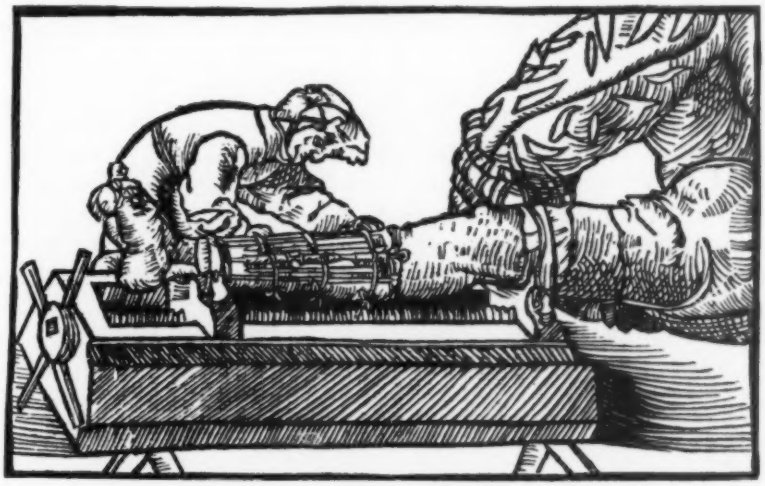

FIG. 7

Mechanical extension and coaptation splints for fracture of the leg. From Bruynswyke, 1525.[6] (The Huntington Library.)

and bowels following a back injury. However, if there was no paralysis he advised the surgeon to "set with your hande the bones and knottes of the back bone as well as ye can and on the fracture lay this plaster: Take cyses meele or beene meel or mylestaffe meele xij ounces, maftik dragatum, gomi arabici of eche two ounces, mumie balyarmeni of eche an ounce and put togyder and make it like a plaster."

Great faith seems to have been placed in these powders. "Maftik" was a much used ingredient. Another powder contained dragon blood. "This powder hath ye power to hele and make stronge the bones and to cause them to growe togyder." He mentions greenstick fractures of the forearm bones. The long bones he sometimes calls "pipes". In the forearm "if both ye pypes be broken so must you have ij servuants, ye one shall holde the pacyent by ye elbowe and the other by the hande . . . set the bone with your hande softely togyder in ye best manner". He cautioned against causing too much pain because it might result in moisture descending into the arm "so myght therof come moch harme".

A fractured finger was laid in an elder-pipe splint and bound together with the sound fingers.

"In the shynne be ii bones, . . . sometyme brekyth the great pype, sometyme the lytel pype . . . the great is more peryllous than the small, and as they bothe be broken that is moost peryl." The splints for the leg must be longer than those for the arm. He admonishes the surgeon not to bind the leg too tight because the "pacyent might come in great harme, payne and fere . . . bynde with clothe depte in oyle of roses". In reducing fractures of the hip and thigh, it is advised that the bone be thrust downward and set again upright.

Although there are several pictures in the book illustrating mechanical methods of extension, Brunschwig scarcely mentions these methods in the text. The absence of reference to Hippocrates is conspicuous.

GIOVANNI DI VIGO (1460–1520)

Another translation into old English is that of a book by Vigo, a surgeon of Italy. He placed much stress on the healing of fractures by external applications of various ointments and concoctions, even going so far as to say that "a broken member . . . can not be duelye restored excepte conjoundyng medicines be applied at the beginnyng". Every few days the bandages were to be opened and the limb anointed with "oyle mertyne, actually hoote laying it on with a hen's feather". Another application was "oyle of roses and cammomylle with the decoctyon of earthe wormes". He used splints either of willow wood or made from a sword scabbard, and he stiffened the bandages with egg white. Manual extension was practised, or when necessary a "tortulare" of Hippocrates was used to accomplish reduction. He was an early advocate of emergency treatment of fractures, contending that "the restauratyon of a broken bone . . . must be done as sone as may be". He also cautioned that the comminuted fracture was very dangerous, because the little

pieces pricked the muscles and the flesh. A bone broken lengthwise was much easier to cure than one broken across. The time required for union was as follows: the shoulder, twenty-four days; the humerus, forty days; the arm, twenty-four days; the thigh, fifty days; and the leg, forty days. "The rounde bone of the knee receiveth no fracture, but is dysplaced and putte oute of ioynte."

SIXTEENTH-CENTURY ENGLAND

The earliest books to appear in the English language were translations such as those already mentioned. In the latter half of the sixteenth century, however, the physicians and surgeons of St. Bartholomew's Hospital and of other London hospitals began to record their own observations and experiences. These books are now rare and are available only in the rare-book collections of a few special libraries such as the Huntington Library and the British Museum.

Thomas Gale (1507–1586), who served with the army of Henry the Eighth in France and gained knowledge of broken bones on the battle fields, classified fractures as simple and compound with subdivisions according to their resemblance to stalks of herbs and vegetables, which must have been rather imaginary. His book is written in the form of conversations in which the author answers questions put by John Yates and John Fielde. Compound fractures included not only those with open flesh wounds, but also those which had "one or more effectes to it connected or ioyned" such as gangrene, inflammation, severe contusion, too much callus, or too dry or too moist callus. He used a sort of drill with a conical-shaped bit for enlarging spaces between fragments, so that arrows or other foreign bodies could be removed.

William Clowes (1540–1604), probably the greatest of early English surgeons, wrote a series of detailed case reports. He advocated the use of external applications of powders and ointments. One ointment, for which he gives the formula, contained forty-four ingredients. His account of reducing a fracture of the femur is worth quoting completely: "First I made two decent towels, and fastened each towel one above the fracture and the other below the fracture. Then I caused two strong men to aprehend and take hold of each towel and I placed myself very neare unto the fracture. Then all things being readie I caused them stronglie to extend or stretch out the member; which being suffiently performed I did elevate or lift up that part of the bone which was depressed and agayne I did also depresse downe the other part of the fractured bone which was borne by or elevated; which being reduced and counited together and rightly restored as near as I could according to natures former union, which being then well joyned I did curiously keepe close the dissevered bones together, and then I caused the men which extended the member by little and little to release their hands, whereby the patient found himself greatly eased of his paynes. . . ." The thigh was then wrapped in linen cloth, soaked in egg white and vinegar. Coaptation splints of willow

wood were bound on and the leg was laid in a sort of bed made of "a good quantitie of great rushes", which was similar to "that famous instrument called of the learned Glossocomium". On account of complications he had a consultation with "my approved good friend Maister Banister". Nevertheless, afterward the patient and friends were "somewhat disconcerted and used some words . . . the chief matter was (besides they were loth to part with their monie) only for that the fractured leg was somewhat shorter than the other. I told them agayne that much might be done in young persons which in aged oftentime did not happily fall out." He then cited a case of a boy of ten who had a badly broken thigh, but who grew up to be a strong man without lameness.

Peter Lowe (or *Love*) (1550–1612) has a chapter on fractures in a book written in the form of a dialogue between Peter and John Lowe. In making a diagnosis, he observed whether there were inequalities easily felt, pain on handling, or a "noyse or bruite" on movement. He called attention to the serious nature of fracture of the femur and used extension for reduction, "one at ye nether part the other at ye upper part, of which one draweth up the other down". If the hands were not sufficient, he used cords and if great force was needed he used the glossocomium. Reduction was done by manipulation in addition to the extension. Splints were made of cardboard, wood, or "white iron", hollow in shape. Three splints were necessary,—the longest was applied to the under part of the fracture as a foundation and the other two were placed on the sides. The patient was advised to eat veal, mutton, and kid to make callus. If the position was not good after consolidation had begun, union might be broken up, first fomenting the part for fifteen days with "hennes, goose or cockes grease to soften the caule (callus)". This was regarded as a serious procedure and Lowe was not much in favor of it, saying that "better it is to suffer a little deformity of the part than losse of the whole body".

In case of a fracture which is accompanied by a dislocation, he advised that the dislocation be reduced first, then the fracture. He described an adhesive paste, made of dragon's blood, mafticke incense, sacrocolla, and fine flower and mixed with white of egg, by which cloth could be made to stick to the skin. This was used instead of sutures to hold wounds together, but he does not mention its use for extension.

Stephen Bradwell, in 1633, wrote a book on emergency surgery, but he did not seem to be interested in fractures. From the following quotation it might be inferred that he disdained to do the work which was being done by the bone-setters who were then becoming prominent in England: "But if, in such a fall, any bone be put out of joint or broken, they must get help of such as are skilful in bone-setting, which art is learned by sight and not by writing."

Like many medical books of his time it has a pious note throughout and closes with a prayer: "Thus have I endeavored a common good. And I beseech our Lord Jesus Christ, that either by his Providence they fall not into any of these Accidents, or els by his blessing upon these or the like meanes, they may safely escape them."

John Banester (1533–1610), a famous London surgeon, reduced fractures by manual extension or by means of the glossocomium "which is done like, as by the sentence of a judge, tormentors stretch upon the racke". He recognized the difference between transverse fractures, in which the "bones make a noyse and crackling", and longitudinal ones, where the part is unnaturally thick. Coaptation splints, bound on with bandages dipped in vinegar and egg albumen, seem to have been his usual method of fixation. After fifteen days he loosened the bandages and put on fomentations of wine, salt, and rose oil. This was done thereafter every seven days. "By these meanes shall nature joyne againe the broken bones (like as sometime also without medicine) which she doth by engendering a callous substance betwixt the broken parts, whereby they are glued together againe."

He treated delayed union by application of warm water and friction, and for malunion he advised softening the callus with various medicinal applications, and then breaking it and correcting the deformity. Complications are recorded as "improportionate growth of callus, paine, inflammation, itching, gangrene and uncomely form of the membre". If there was evidence of gangrene, he sacrificed the part affected. His schedule of union was as follows: the leg bones, forty days; the rib, twenty-one days; and the humerus, twenty-seven to forty days.

The method of treatment which seems to have been most prominent in London during the sixteenth century is the external application of medicine to the fractured limbs. This was probably due to the influence of Guy de Chauliac. However, the London surgeons did not employ his extension methods very generally; at least no mention of permanent extension with weight and pulleys is found in their writings. Physiotherapy was used in various forms. In the history of St. Bartholomew's Hospital (founded in 1123) there is mentioned the building of a "hot house for the poor to sweat in" (1555). Fractures were treated as emergencies, as shown by the instructions to the senior beadle that such cases were to be admitted at once.

AMERICAN INDIANS

Among the American Indians, not only the medicine men, but also the laymen were familiar with fractures and their treatment. It is significant that the splints they used were long enough to immobilize the neighboring joints,[20] while those employed by the surgeons of medieval Europe stopped short of the joints. One form of splint was made of wet rawhide, which was pliable. It was shaped to the limb after reduction of the fracture and, on drying, formed a firm, stiff cast.[16]

The Indians also used coaptation splints made of cedar wood. Treatment of a fractured humerus is described by Hoffman. The splint "consisted of twelve or fifteen strips of cedar wood, each of which was about a quarter of an inch thick, three-fourths of an inch wide, and from six to eight inches in length". Near the ends they were held together by

sinews woven between them, making an intact unit which was applied to the arm and held there by tying the sinews together. Enough space was left between the splints for applying soothing lotions and for dressing the wound of the compound fracture. Another method cited was that of splints made of birch bark soaked in water until quite soft.[22] They were then carefully fitted to the limb and tied with bark thongs. On drying, they became stiff and firm. There is no record of the use of extension, but, nevertheless, very few crippled and deformed Indians were to be seen.

According to Andros, a case of compound fracture of the leg, four or five inches above the ankle, was treated as follows: A semicylindrical piece of bark, larger than the limb, was applied to the back of the leg and thigh. It was cut deeply at both sides of the knee, so that it could be bent to an inclined plane. The splint was then filled with soft clay, and the limb was imbedded in it from heel to groin, with the exception of an opening which was left for the wound. "The wound was kept clean and dressed with the thick mucilage of elm bark. The patient made a rapid recovery, with but little shortening."

Specimens of fractured bones have been found in Indian graves of the Southwest. Some of them are united in good position, others with some deformity. The one illustrated (Fig. 2) shows signs of having been infected as well as shortened.

SUMMARY

The high points in civilization which have produced the best in all the arts naturally were the times of greatest achievement in medicine and surgery. If we were to pick out one age and people which shone the brightest in this respect, it would be Greece in the fifth century, and, if one man were to be selected, he would be Hippocrates.

The next age of importance is probably the eleventh and twelfth centuries when the Arabian school flourished, the most prominent member of which was Avicenna.

In the fourteenth century we come to another high point which is brought to our knowledge by the writings of Guy de Chauliac.

Again, in the sixteenth century, Ambroise Paré seems to tower above the others of his time.

The most striking fact encountered in such a study as this is that many of our supposedly modern inventions and methods—some of which bear names of doctors of the nineteenth or twentieth centuries—were discovered and practised 2,000 or 3,000 years ago.

A distinguished scholar [3] once said: "Whenever I get a new idea I look up and see which Greek author had expressed it best."

REFERENCES

1. Andros, F.: The Medicine and Surgery of the Winnebago and Dakota Indians. J. Am. Med. Assn., I, 116, 1883.
2. Banester, John: The workes of that Famous Chirurgian Mr. John Banester. London, 1633. (The Huntington Library, San Marino, California.)

3. Bennet, J. O'Donnell: Much Loved Books. New York, Horace Liveright, Inc., 1932.
4. Blum, Lester: The Early History of Permanent Extension in the Treatment of Fractures. Internat. Abstract Surg., LXI, 417, 1935.
5. Bradwell, Stephen: Helpes for Suddain Accidents. London, 1633. (The Huntington Library.)
6. Bruynswyke, Jherome of: The noble experyence of the vertuous handy warke of surgeri. London, 1525. (The Huntington Library. Three other known copies,—at the British Museum, Oxford, and Cambridge.)
7. Buck, A. H.: The Growth of Medicine from the Earliest Times to about 1800, pp. 9, 157. New Haven, Yale University Press, 1917.
8. Cave, A. J. E. (Assistant Conservator, Royal College of Surgeons Museum, London): Personal communication.
9. Clowes, Wyllyam: A Prooved Practice for all young Chirurgians. London, 1588. (The Huntington Library. Only two other copies,—at the Royal College of Surgeons Library, London, and at Oxford.)
10. Gale, Thomas: Certaine workes of Chirurgie. London, 1563. (The Huntington Library. Three other known copies,—at the British Museum, Oxford, and Cambridge.)
11. Garrison, F. H.: An Introduction to the History of Medicine. With Medical Chronology, Suggestions for Study and Bibliographic Data. Ed. 3, p. 148. Philadelphia, W. B. Saunders Co., 1921.
12. Guido de Cauliaco: The Questyonary of Surgeans. London, 1541. (The Huntington Library. Only two other copies,—at the British Museum and the Chapin Library.)
13. Guy de Chauliac (A.D. 1363): On Wounds and Fractures. Translated by W. A. Brennan. pp. 73–76, 133–153. Chicago, W. A. Brennan, 1923.
14. Hippocrates:—Genuine Works. Translated from the Greek with a Preliminary Discourse and Annotations, by Francis Adams. Vol. II, pp. 23–156. New York, William Wood & Co., 1891.
15. Hoffman, W. J.: The Practice of Medicine and Surgery by the Aboriginal Races of the Southwest. Med. and Surg. Reporter, XL, 157, 1879.
16. Kuykendall, G. B.: Medicine among the Aborigines. Med. and Surg. Reporter, XXXIII, 181, 1875.
17. Lowe (or Love), Peter: Art of Chirurgerie. London, 1612. (The Huntington Library.)
18. Paré, Ambroise: Oeuvres Complètes. Collected and Edited by J.-F. Malgaigne. Vol. II, pp. 316–328. Paris, J.-B. Baillière, 1840.
19. Smith, Edwin: Surgical Papyrus. Published in Facsimile and Hieroglyphic Transliteration with Translation and Commentary in Two Volumes, by J. H. Breasted. Vol. I, pp. 350–357. Chicago, The University of Chicago Press, 1930.
20. Stone, Eric: Surgery among the North American Indians. Am. J. Surg., XIII, 579, 1931.
21. Sudhoff, Karl: Essays in the History of Medicine, p. 163. New York, Medical Life Press, 1920.
22. Toner, J. M.: Some Points in the Practice of Medicine among the North American Indians, with Incidental Reference to the Antiquity of the Office of the Physician. Virginia Med. Monthly, IV, 334, 1877.
23. Vigo, Johannes: The most excellent worckes of Chirurgery. A Translation by Traheron. London, 1550. (The Huntington Library.)

SKELETAL AND EXTRASKELETAL TUBERCULOUS LESIONS ASSOCIATED WITH JOINT TUBERCULOSIS

BY GEORGE A. DUNCAN, M.D., NORFOLK, VIRGINIA

Fellow of the New York Orthopaedic Dispensary and Hospital, New York, N. Y.

The purpose of this paper is to analyze the incidence of skeletal and extraskeletal tuberculous lesions as a complication in 555 patients with joint tuberculosis.

Joints are infected with tuberculosis by way of the circulatory system, and the determination of the site of the primary lesion is difficult and often impossible. Many consider the lung the portal of entry. However, various workers, quoted by MacCallum, have shown that tubercle bacilli, brought into contact with any mucous membrane, can be absorbed without leaving a destructive lesion at the point of entrance, and can then spread rapidly throughout the body, lodging in lymphoid tissue and forming a possible focus. If we accept this theory, the nasopharyngeal and the gastro-intestinal mucous membranes must be included as portals of entry.

No attempt has been made to establish the primary source of the tuberculosis in this series of patients. However, in this connection, it is significant that 238 patients (43 per cent.) in this series presented no demonstrable skeletal or extraskeletal tuberculous lesion, clinically or roentgenographically, other than the single joint lesion for which they were originally treated.

NATURE OF THE MATERIAL

The 555 patients studied were treated in the New York Orthopaedic Dispensary and Hospital during the years 1923 to 1933. These patients represented in the main an ambulatory group on their admission to this Clinic and were selected cases only to that degree. Those patients who were very poor operative risks, due to advanced or fulminating pulmonary tuberculosis, were referred to sanatoria, the greater percentage of these being sent to Sea View Hospital. All of the tuberculous joints in this series were arthrodesed and the patients were followed for at least one year after operation, with an average follow-up of four years.

PATHOLOGICAL PROOF OF JOINT TUBERCULOSIS

In 379 of the 555 patients, the tuberculous nature of the joint lesion was proved by one or more of the following methods: microscopic section of biopsy material positive for tuberculosis, 340 cases; positive guinea-pig inoculation of biopsy material, 269 cases; smears of aspirated pus positive for tubercle bacilli, 11 cases. The lesions in the remaining 176 patients, in whom no pathological proof was found, were all in the vertebral bodies. In these patients, the location of the disease was such that pathological

TABLE I

LOCATION OF DISEASE

Site	No. of Patients
Spine	228
Hip	154
Knee	101
Ankle	27
Wrist	19
Shoulder	11
Elbow	8
Tarsus	7
Total	555

material was not available, but the clinical and roentgenographic findings were typical of tuberculosis.

TUBERCULIN SKIN TESTS

The patients were tested either by the von Pirquet or by the Mantoux method. Of the 538 patients for whom there were records, only one gave a negative reaction. The test was repeated three times in this case and each time a negative result was recorded. This patient was a baby, six months old, and the diagnosis of tuberculosis of the spine was as definite as possible in the absence of pathological material for examination. The lungs in this patient also showed evidence of the childhood type of tuberculosis. Therefore, a negative tuberculin test is of great value in excluding the diagnosis of tuberculosis of the bones and joints.

SEX AND DURATION OF SYMPTOMS

An analysis of the sex and age of the entire group showed nothing significant. The sexes were about equally divided, and the ages ranged from seven months to fifty-eight years, with an average age of seventeen years. The average duration of symptoms at the time of admission to the hospital was six years, the shortest duration being two weeks and the longest thirty-three years.

TABLE II

INCIDENCE OF PULMONARY TUBERCULOSIS IN 555 PATIENTS WITH JOINT TUBERCULOSIS

Type of Lesion	Patients	Per Cent.
Active pulmonary or bronchial gland	69	12.43
Inactive pulmonary or bronchial gland	199	35.86
No demonstrable pulmonary lesion	287	51.71

FAMILY HISTORY

Of 299 patients for whom there were records, 26 per cent. gave a family history of tuberculosis. Henderson found a positive family history in 19 per cent. of his cases of tuberculosis of the hip and 9 per cent. in cases of tuberculosis of the knee.

COMMENT ON THE PULMONARY LESIONS

A recapitulation of the pulmonary findings in Table II reveals that 48 per cent. of the patients with joint tuberculosis had pulmonary or bronchial-gland tuberculosis. There were only 12 per cent. in whom the disease was active and 36 per cent. in whom the disease was inactive. The activity or inactivity of the lesions shown in Table II was determined by a correlation of the physical and roentgenographic findings. While sputum examination is one of the positive factors in the determination of the activity of the pulmonary lesion, it was not done in this series of cases. No attempt has been made to classify further the lesions in these patients. However, Reisner studied the pulmonary findings in a somewhat similar group of patients and found "a strikingly large proportion of the discrete nodular disseminated forms of various quantitative extent, ranging from a small number of foci of the abortive type with frequent indications of healing and calcification . . . through various degrees of dissemination of the chronic miliary and acinonodose type . . . to the typical acute miliary tuberculosis". Other writers have found a closely corresponding incidence of pulmonary lesions in groups of patients with bone and joint tuberculosis (approximately 48 per cent.). Löwenstein, in reviewing the post-mortem examinations in 400 cases of skeletal and genito-urinary tuberculosis, found the lungs free from changes or showing insignificant apical scars in 60 per cent. of the patients with skeletal lesions.

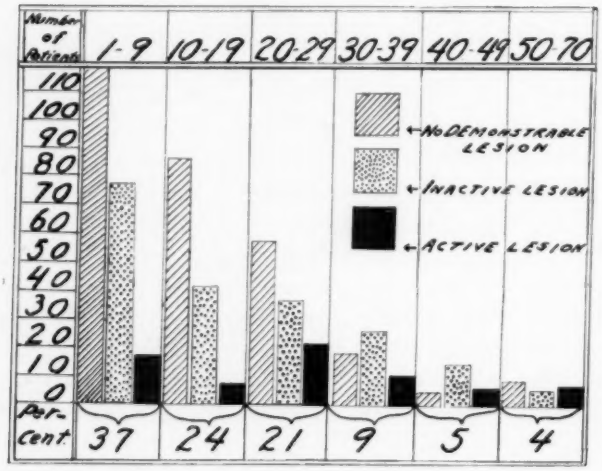

FIG. 1

Incidence of pulmonary tuberculosis according to decades.

Involvement of the lungs with tuberculosis in the respective age groups of this series is shown in Figure 1. The proportion of patients with inactive pulmonary tuberculosis and of those with no demonstrable

pulmonary lesion is very high in the first two decades of life, while the proportion of patients with active tuberculosis is much greater after the second decade. An explanation of this variation is that the primary lesion is probably in the lymphoid tissue in a greater number of cases in the first two decades of life, while after that period the general incidence of pulmonary tuberculosis increases.

The pulmonary tuberculous lesions associated with joint tuberculosis in this series were relatively benign in character. The significant finding which demonstrated the benign nature of the pulmonary lesion was the comparatively low percentage (12.0) of patients with active pulmonary tuberculosis.

The benign nature of the pulmonary lesion is also demonstrated in Table III. Retrogression or healing of the pulmonary lesion (active or inactive) frequently occurs after treatment of the joint lesion by operative fusion. In only ten patients could the pulmonary disease be considered as progressing. These ten patients include the nine who died of pulmonary tuberculosis (Table V) and the one who developed active pulmonary tuberculosis following a spine fusion, when the original examination of her lungs was negative (Table III).

The benign nature of the pulmonary lesion cannot be considered as the only cause of the retrogression of the disease. Rest in bed, following operative fusion of the diseased joint, and the consequent healing of the local focus improved the patient's general health. The healing of the pulmonary lesion must be considered to be due in part to elimination of the joint focus following operative procedures, for a large proportion of patients in the active pulmonary group had sanatorium treatment or rest in

TABLE III

COMPARATIVE STATUS OF PULMONARY LESIONS ON FOLLOW-UP EXAMINATIONS

On Admission			On Follow-Up Examinations							
			Active		Inactive		No Demonstrable Lesion		Deaths	
Pulmonary Status	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.
Active tuberculosis	69	12.43	7	10.14	40	57.97	0	0.00	22	31.89
Inactive tuberculosis	199	35.86	0	0.00	187	93.97	0	0.00	12	6.03
No demonstrable lesion	287	51.71	1	0.35	0	0.00	275	95.82	11	3.83
Total	555	100.00	8	1.44	227	40.90	275	49.55	45	8.11

bed at home under the care of a physician before their joint lesions were treated surgically.

Operative procedures are not attempted either in children or in adults in whom the pulmonary disease is far advanced or when the patient is markedly undernourished. Ethylene anaesthesia is now used almost exclusively for patients with any tuberculous lesion, as we feel it is the safest from all standpoints for this class of patients. The author does not believe that the presence of mild or moderately advanced pulmonary tuberculosis in any patient should deter one from operating on the tuberculous joint lesion. For those patients who are undernourished a short period of building up is recommended before operative procedures are attempted.

INCIDENCE OF TUBERCULOUS TONSILS

From 100 patients the tonsils were removed and examined microscopically. A single section was made through the most suspicious area of each tonsil and in twenty-four cases it was found to be tuberculous. Serial sectioning might have revealed a higher incidence of tuberculosis. Neither guinea-pig inoculation nor staining for tubercle bacilli was attempted. Snyder reported an incidence of 5 per cent. of tuberculosis of the tonsils in 100 patients with proved bone and joint tuberculosis. Pathological reports of over 30,000 tonsillectomies on unselected patients, collected from the literature,* show the incidence of tuberculosis to average only 2.8 per cent.

The tuberculous tonsils presented no ulcerations or other characteristic external features which would suggest a diagnosis of tuberculosis before or after their removal, except occasionally a firm nodule was palpable postoperatively in the gross specimen.

Healing followed the tonsillectomy equally well whether or not the tonsils proved tuberculous. Absence of gross pathological changes and good healing power after tonsillectomy have been noted by almost all writers on tonsillar tuberculosis.

Ten (42 per cent.) of the twenty-four patients with tonsillar tuberculosis also had pulmonary tuberculosis. Of these, two had active pulmonary tuberculosis and eight inactive. This percentage of pulmonary tuberculosis associated with tuberculosis of the tonsils is about the same as that which occurred in the whole group of 555 patients, or 48 per cent.

The indications for tonsillectomy in this group were hypertrophy, obstruction of the pharynx, and recurrent attacks of tonsillitis or cervical adenitis.

Removal of the tonsils (tuberculous or non-tuberculous) in this series had no apparent effect on the healing of the joint lesion or on the appearance of multiple tuberculous foci. The tuberculous tonsil, as demonstrated, is a relatively benign lesion. However, as the tonsils are another

* See References: Korns, MacCready and Crowe, Mitchell, Morris, Mullin, Rhoads, Welch, Weller, and Wilkinson.

TABLE IV

INCIDENCE OF TUBERCULOUS LESIONS ASSOCIATED WITH JOINT TUBERCULOSIS

Associated Tuberculous Lesions	Joint Primarily Diseased							Total (*Cases*)
	Spine (*Cases*)	Hip (*Cases*)	Knee (*Cases*)	Ankle (*Cases*)	Tarsus (*Cases*)	Wrist (*Cases*)	Shoulder (*Cases*)	
	38	25	14	7	2	2	3	91
Hip	11		3	2				16
Kidney	7	3	2	1				13
Sacro-iliac joint	4					1		5
Knee	2	1		1				4
Sternum	2							2
Shoulder	4							4
Peritoneum	2	1						3
Tendon sheaths	1	3	1		2	1		8
Epididymis	1		1	1				3
Greater trochanter	1							1
Metatarsophalangeal joint	1							1
Fallopian tubes	1	1				1		3
Tonsils	8	8	4	2	1		1	24
Spine		6	2	2	1	1	1	13
Ischium		1						1
Wrist		1			1			2
Tarsus		1	1					2
Tibia		1	1					2
Ankle		1			1			2
Metacarpophalangeal joint		1						1
Liver		7						7
Skull				1				1
Skin tuberculides			1	1				2
Digits				1				1
Caecum							1	1
Femur			1					1
Total	45	36	17	12	6	4	3	123

TABLE V

CAUSE OF DEATH IN RELATION TO PULMONARY DISEASE

Cause of Death	Status of Pulmonary Lesion on Last Examination			Total
	Active	Inactive	No Demonstrable Lesion	
Pulmonary tuberculosis	7	2		9
Miliary tuberculosis	9	1	2	12
Tuberculous meningitis	2	3	1	6
Amyloidosis	1	1	1	3
Pulmonary hemorrhage	1			1
Pneumonia	2	3		5
Shock		2	1	3
Pulmonary embolus			2	2
Acute nephritis			1	1
Carcinoma of stomach			1	1
Carcinoma of throat			1	1
Cause unknown			1	1
Total	22	12	11	45

possible tuberculous focus and are found to be involved in a high percentage of patients with joint tuberculosis, their removal is recommended where feasible and certainly in those cases in which the patients' general health is poor.

INCIDENCE OF GENITO-URINARY TUBERCULOSIS

In this series, there were thirteen patients (2 per cent.) with known tuberculosis of the kidney, and three patients (0.5 per cent.) with tuberculous epididymitis. Nephrectomies were done in all cases of tuberculous kidney except three.

The incidence of tuberculous lesions of the genito-urinary system is not high, but careful periodic examinations of the urine are certainly in order as a means of recognizing another possible tuberculous focus. Urine which contains red and white blood cells in a catheterized specimen should be stained for tubercle bacilli, and a guinea-pig inoculation should be made. Harris reported only one case of renal tuberculosis over a ten-year period in 392 patients with bone and joint tuberculosis. However, in a subsequent eighteen-month period, when careful periodic examinations of the urine were made, 13.8 per cent. of the patients were found to have an associated renal tuberculosis.

MULTIPLE TUBERCULOUS FOCI

Ninety-one, or 16 per cent., of the 555 patients had 123 associated skeletal and non-skeletal tuberculous lesions other than pulmonary disease (Table IV). Of this particular group, twenty-one patients (23 per cent.) had active pulmonary tuberculosis; forty-two (46 per cent.) had inactive pulmonary tuberculosis; and twenty-eight (31 per cent.) showed no evidence of pulmonary involvement. This is a greater proportion (69 per cent.) of pulmonary disease than was evidenced in the whole group.

In the seven patients who had tuberculosis of the kidney associated with tuberculous spondylitis, the vertebral lesions were localized in the lower dorsal or lumbar vertebrae, with the majority at the dorsolumbar junction.

Intestinal and laryngeal tuberculosis were rarely encountered in this group of patients. Pagel has noted that laryngeal and intestinal involvement is much more frequent in association with isolated pulmonary lesions than with pulmonary changes which are associated with other extrapulmonary manifestations.

Amyloidosis was encountered as a complication in seven patients, all of whom had tuberculosis of the hip with sinus formation. Three of these patients died of amyloidosis.

MORTALITY STATISTICS

The forty-five deaths (8 per cent.) in this series (Table V) will compare very favorably with a similar group of patients treated by conservative means. In a similar conservatively treated group of tuberculous knees reported by Hibbs and von Lackum, the mortality was 9 per cent.; and, in a group of tuberculous hips reported by Smith and Watters, the mortality was 24 per cent. Cleveland reported a mortality of 28.5 per cent. in a group of 210 patients whose joint tuberculosis was treated surgically, while in a group of slightly over 300 cases, which were rejected as unsuitable for surgery, the mortality was over 80 per cent.

Cleveland's statistics are appalling and no doubt are due to the type of patient treated at Sea View Hospital. In regard to these patients he stated: "Coming from the lower classes of society, from poverty and disease, of less fit racial strains, they have been discarded by most of the city's hospitals and sent to Sea View Hospital for ultimate disposal."

Therefore, the true mortality rate in surgical tuberculosis is probably a mean between Cleveland's finding of 28.5 per cent. and that of 8 per cent. in this series.

As one would expect, the greatest number and percentage of deaths was in the group of patients with active pulmonary tuberculosis. The two most common causes of death in this series were pulmonary and miliary tuberculosis. Reisner, in his review of the literature, brings out the point that acute generalized miliary tuberculosis is rare in chronic pulmonary lesions, whereas in extrapulmonary lesions the opposite seems to be the case. This fact, as also noted in this series, is a further indication that the

pronounced tendency to generalization constitutes a distinct characteristic of the extrapulmonary lesions.

COMMENT

In this study it was found that 317 patients (57 per cent.) had tuberculous skeletal or extraskeletal lesions associated with joint tuberculosis. This determination reminds one that tuberculosis is a systemic disease and that the various manifestations of this infection cannot be considered as separate entities.

Tuberculous joints are disabling, and distressing deformities occur. Operative fusion of these joints is now accepted by most surgeons as the best method of hastening and effecting a satisfactory cure.

Among the main objections to operative fusion has been the erroneous belief that there is an increase in the mortality and a greater dissemination of the disease. The mortality rate of 8 per cent. in this series of operative cases over a postoperative period averaging four years is as low as the mortality rates reported in patients treated by conservative methods. While a likelihood of disseminating the disease sounds plausible, it cannot be proved. The multiple lesions which are a characteristic of the extrapulmonary form of tuberculosis occur in any series. The incidence of multiple lesions (only 16 per cent.) in this series (excluding pulmonary disease and deaths) is not high. Therefore, dissemination is not a common postoperative factor or complication as the result of operation on tuberculous joints.

SUMMARY

1. Of this series of 555 patients with joint tuberculosis, the diagnosis was proved in all but 176 in whom the disease was localized in the vertebral bodies.

2. Active pulmonary tuberculosis was found in 12 per cent. of the patients, inactive in 36 per cent., and no demonstrable lesion in 52 per cent.

3. In this series pulmonary lesions, when associated with joint tuberculosis, were relatively benign in character.

4. Tuberculosis was found in 24 per cent. of the tonsils removed.

5. Only one negative tuberculin test was found in this series of patients. Therefore, a negative tuberculin test is of great value in excluding the diagnosis of tuberculosis of the bones and joints.

6. Tuberculous disease of the genito-urinary tract was found in 2.5 per cent. of the patients.

7. Ninety-one, or 16 per cent., of the patients in this series had 123 associated tuberculous lesions other than pulmonary disease.

8. The mortality rate was 8 per cent. (forty-five patients) in this series.

REFERENCES

CLEVELAND, MATHER: Surgical Treatment of Joint Tuberculosis. Surg. Gynec. Obstet., LXI, 503, 1935.

HARRIS, R. I.: Observations on the Pathology of Surgical Tuberculosis. With Particular Reference to the Incidence of Tuberculous Bacilluria. Am. J. Surg., X, 514, 1930.

HENDERSON, M. S.: Combined Intra-Articular and Extra-Articular Arthrodesis for Tuberculosis of the Hip Joint. J. Bone and Joint Surg., XV, 51, Jan. 1933.

HENDERSON, M. S., AND FORTIN, H. J.: Tuberculosis of the Knee Joint in the Adult. J. Bone and Joint Surg., IX, 700, Oct. 1927.

HIBBS, R. A., AND VON LACKUM, H. L.: End-Results in Treatment of Knee Joint Tuberculosis. J. Am. Med. Assn., LXXXV, 1289, 1925.

KORNS, J. H.: Primary Tuberculosis of Tonsils and Adenoids among Chinese. China Med. J., XXXIX, 899, 1925.

LÖWENSTEIN, E.: Die Tuberkulose als Organsystem-Erkrankung. Wiener klin. Wchnschr., XXXVI, 549, 1923.

MACCALLUM, W. G.: A Text-Book of Pathology. Ed. 3. Philadelpha, W. B. Saunders Co., 1924.

MACCREADY, P. B., AND CROWE, S. J.: Tuberculosis of the Tonsils and Adenoids. A Clinical and Roentgen-Ray Study of Fifty Cases Observed for Five Years after Operation. Am. J. Dis. Child., XXVII, 113, 1924.

MITCHELL, A. P.: Primary Tuberculosis of the Faucial Tonsils in Children. J. Pathol. and Bacteriol., XXI, 248, 1917.

MORRIS, A. G.: Clinical and Pathologic Study of Tonsil Cases. Ann. Otol., Rhinol. and Laryngol., XXXII, 864, 1923.

MULLIN, W. V.: An Analysis of Some Cases of Tubercles in the Tonsil. J. Am. Med. Assn., LXXX, 1211, 1923.

YEAR BOOKS OF THE NEW YORK ORTHOPAEDIC DISPENSARY AND HOSPITAL, 1900–1911. New York, Gazlay Brothers.

PAGEL, W.: Pathologische Anatomie der hämatogenen Streuungstuberkulose. Ergebn. d. ges. Tuberk., V, 231, 1933.

REISNER, DAVID: The Relations between Extrapulmonary and Pulmonary Tuberculosis. Am. Rev. Tuberc., XXX, 375, 1934.

RHOADS, P. S.: Pathologic Changes in the Tonsils. Their Relation to Usual Indications for Tonsillectomy. Arch. Otolaryngol., XV, 599, 1932.

SMITH, A. DEF., AND WATTERS, W. H.: Tuberculosis of the Hip. End-Results of One Hundred and Fifty Cases. J. Am. Med. Assn., XC, 189, 1928.

SNYDER, C. H.: The Association of Pulmonary and Other Tuberculous Lesions in Cases of Proven Bone and Joint Tuberculosis. J. Bone and Joint Surg., XV, 924, Oct. 1933.

WELCH, A. S.: Pathologic Changes in the Faucial Tonsils. J. Am. Med. Assn., LXXXIX, 2180, 1927.

WELLER, C. V.: The Incidence and Histopathology of Tuberculosis of the Tonsils. Based on Eight Thousand Six Hundred Tonsillectomies. Arch. Int. Med., XXVII, 631, 1921.

WILKINSON, H. F.: Pathologic Changes in Tonsils. Study of 10,000 Pairs of Tonsils, with Special Reference to Presence of Cartilage, Bone, Tuberculosis and Bodies Suggestive of Actinomycosis. Arch. Otolaryngol., X, 127, 1929.

BONE ATROPHY AND ABSORPTION

Experimental Observations

BY PAUL E. McMASTER, M.D., LOS ANGELES, CALIFORNIA

From the Division of Orthopaedics, Department of Surgery of the University of Chicago

While studying experimentally the influence of circulatory changes on the repair of fibular defects which were made by subperiosteal resections and simple osteotomies in dogs, the author found an unexpected and high incidence of non-union and atrophy of fibular fragments. Not only did decalcification occur in the ununited fibular fragments, which was evidenced by a definite decrease in roentgenographic density, but actual absorption of the fragment ends, as well as concentric absorption of the fragment shafts, was noted.

EXPERIMENTAL WORK

Forty-eight healthy adult dogs were used and aseptic operative technique was employed. In twelve of these dogs, infections of the operative wounds developed and the animals were discarded, leaving thirty-six dogs for study. In twenty-two of these animals, fibular fragments, measuring approximately one and five-tenths millimeters, were resected subperiosteally from near the upper ends of both fibulae. Unilateral lumbar sympathectomy, including usually three and sometimes four

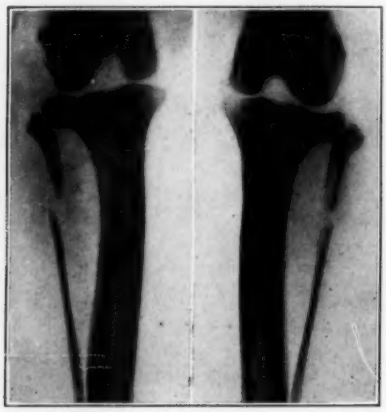

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FIG. 1-A

Dog 147. Roentgenograms, taken immediately after operation, showing the amount of bone removed subperiosteally at the time when a left lumbar sympathectomy was done.

Right Left

FIG. 1-B

Dog 147. Roentgenograms showing the condition eleven months after operation. Note the atrophy and absorption of the fragment ends and the marked concentric atrophy of the fibular fragments throughout the entire length.

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FIG. 2-A

Dog 483. Roentgenograms, taken sixteen days after operation, showing the amount of bone removed at the time of a right femoral-vein ligation.

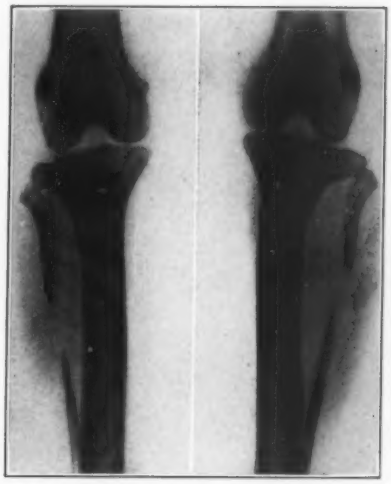

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FIG. 2-B

Dog 483. Roentgenograms, taken five months after operation, showing bilateral absorption and atrophy of the fibular fragments. Note the sharp pointing of the latter.

ganglia with the intervening chain from the sacral promontory upward, was performed on twelve of the twenty-two animals. Five had unilateral ligation of the femoral vein in the proximal portion of the thigh, while two had unilateral arterial ligations in the same location. In the remaining three cases, the sciatic nerve was severed in the proximal part of the thigh.

A simple linear subperiosteal osteotomy, near the upper ends of both fibulae, was done in the other fourteen animals, using small bone-biting forceps. Of these, six had unilateral lumbar sympathectomy and eight had unilateral ligation of the femoral vein in the proximal part of the thigh.

EXPERIMENTAL RESULTS

In nine, or 41 per cent., of the twenty-two dogs from which fibular segments were removed subperiosteally, healing failed to take place bilaterally; in addition, the ends of the fibular fragments showed absorption. Six of these had had sympathectomies (Figs. 1-A and 1-B), while three had had venous ligations (Figs. 2-A and 2-B). In one case in the latter group, there resulted non-union and marked absorption on the non-ligated side and a fibrocartilaginous union on the ligated side.

Absorption was marked in some of the cases. The fragment ends became sharply pointed and the fibular defect, which at first measured approximately one and five-tenths millimeters, increased to nearly one centimeter in some cases and more in others. (See Figures 3-A and 3-B.)

In the three dogs that had sciatic-nerve sections, as well as in the

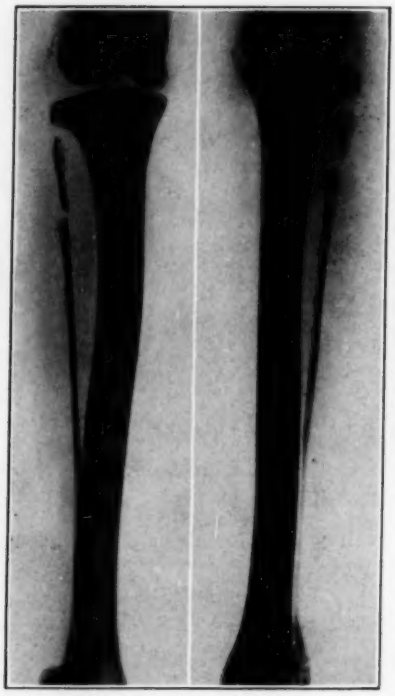

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FIG. 3-A

Dog 48. Roentgenograms showing the fibulae three weeks after subperiosteal bone resections and lumbar sympathectomy had been done.

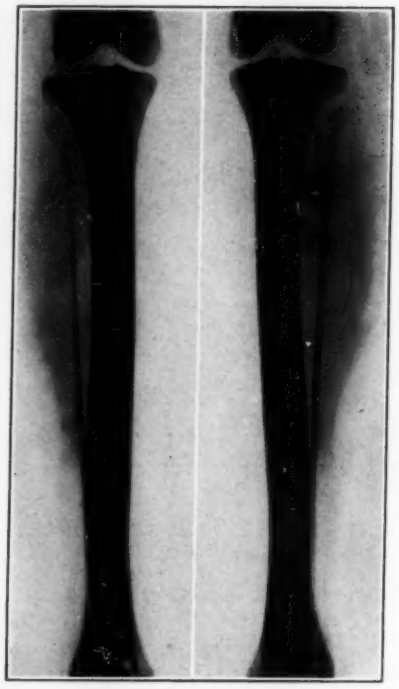

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FIG. 3-B

Dog 48. Roentgenograms taken six months after operation. Marked bone atrophy and absorption of the fibular fragments are present. Note especially the marked pointing of bone ends and the width of the fibular defects.

two with arterial ligations, bilateral healing resulted. Of the fourteen animals that had had bilateral simple osteotomies—six with unilateral sympathectomy and eight with unilateral venous ligation—only one showed non-union, atrophy, and absorption; in the other cases bilateral healing occurred. The animal exhibiting non-union had a right femoral-vein ligation and union occurred on this side, but not on the opposite side.

Experimental results obtained in this series of forty-eight dogs are shown in Tables I and II.

PATHOLOGICAL OBSERVATIONS

Microscopic studies were made of the fibulae in the cases in which union resulted, and the usual picture of true bony callus was seen. Sections were made across the gap between the fragment ends in those cases in which healing did not occur. These ends were often sharply pointed or serrated, and the gap was filled by fibrous and muscular tissue. Osteoclastic lacunar absorption by giant cells was noted at the bone ends and on the cortical surfaces. (See Figure 4-A.) In addition to this there

TABLE I

BILATERAL FIBULAR SEGMENTS (1.5 MILLIMETERS) RESECTED

Procedure	End Results			Total (*Dogs*)
	Infected and Discarded (*Dogs*)	Healed (*Dogs*)	Non-Union (*Dogs*)	
Unilateral lumbar sympathectomy	7	6	6*	19
Unilateral femoral-vein ligation	0	2	3*†	5
Unilateral femoral-artery ligation	0	2	0	2
Unilateral sciatic-nerve section	0	3	0	3
Total	7	13	9	29

* With atrophy and absorption of ends of fragments.

† One of these showed fibrocartilaginous union on the ligated side, but non-union with atrophy and absorption on the opposite side.

was absorption by mononuclear cells, without any evidence of giant-cell osteoclasts, both at the bone ends and on the cortical surfaces. (See Figure 4-B.) The marrow spaces revealed more than the usual amount of hyperaemia, which was marked in several places. In some regions engorged blood vessels were closely approximated to serrated bony surfaces. There was neither gross nor histological evidence of infection.

TABLE II

BILATERAL FIBULAR OSTEOTOMIES

Procedure	End Results			Total (*Dogs*)
	Infected and Discarded (*Dogs*)	Healed (*Dogs*)	Non-Union (*Dogs*)	
Unilateral lumbar sympathectomy	4	6	0	10
Unilateral femoral-vein ligation	1	7	1*†	9
Total	5	13	1	19

* With atrophy and absorption of ends of fragments.

† This animal showed healing on the ligated side, but not on the opposite side.

FIG. 4-A

Serration at end of fibular fragment, showing giant-cell osteoclasts producing lacunar absorption.

It is interesting that bone absorption was noted microscopically, not only at and near the fragment ends, but also at a considerable distance from them; this explained the concentric shaft atrophy seen roentgenographically.

COMMENT

In thirteen of the twenty-two dogs with resected fibular segments bilateral healing took place, and in all but one of the remaining nine cases bilateral non-union resulted. Of the fourteen dogs with simple osteotomies all except one showed bilateral bony union. Since nearly all of the cases exhibited either bilateral healing or bilateral non-union, in spite of the accompanying unilateral procedures of sympathectomy, or venous or arterial ligation, or sciatic-nerve section, these factors with their associated circulatory changes had no appreciable influence on the resulting non-union. Also these factors had no demonstrable influence either on the degree or on the rapidity of bone atrophy.

In every case that exhibited a marked degree of bilateral absorption of fragment ends a segment of each fibula had been resected. In one of

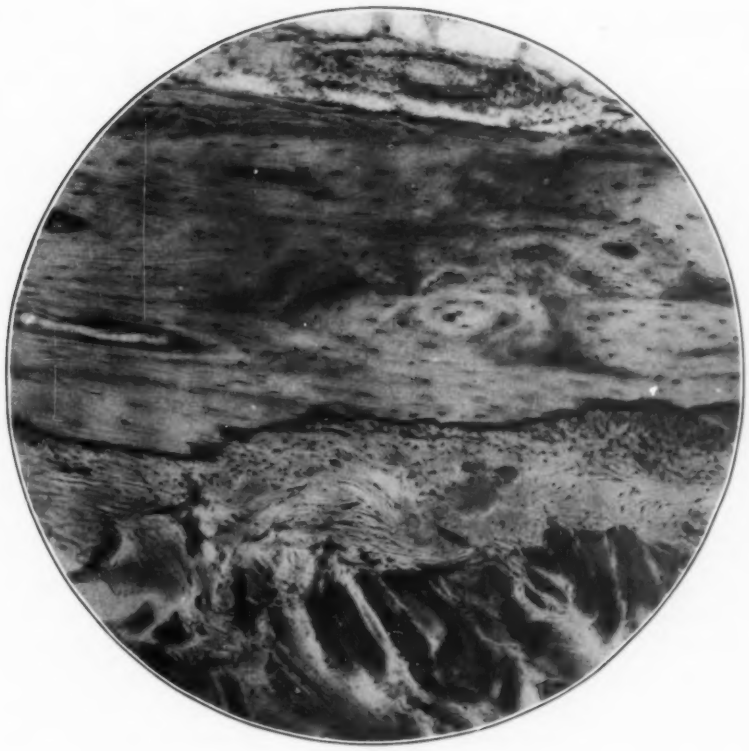


FIG. 4-B

Cortical absorption by mononuclear cells seen at cortical margin.

the fourteen cases in which bilateral simple osteotomies were done, there was non-union with absorption of fragment ends on one side.

A review of the causes leading to non-union of fractures in man reveals a number of factors. Some writers, such as Nutter, have stated that constitutional causes are more numerous than local factors in the prevention of union. Campbell, in discussing the etiology of non-union, states that the causes are both constitutional and local, but not more than 1 per cent. can be attributed to constitutional factors. Among the most important local causes of non-union are: (1) non-apposition of the fractured ends, whether due to loss of bone, to overriding, or to overpull; (2) interposition of the soft parts; (3) infection or neoplasm; (4) faulty immobilization; and, perhaps, (5) circulatory disturbances. Steindler, in commenting on bone regeneration mentions that callus may be stimulated by slight displacement and mobility, also by friction and mechanical and static irritation. However, he mentions that an abnormal amount of mechanical irritation, such as an excess of motion and of physical forces, acts destructively on callus formation.

All but one of the cases of non-union occurred in those animals in which fibular segments had been removed, despite the fact that there was

a continuous bridge of periosteum between the fragments. The author does not offer the above evidence in refutation of the classic experimental studies of Syme and Ollier or of the numerous subsequent investigations in which the osteogenetic properties of periosteum were demonstrated by the occurrence of healing when subperiosteal portions of bone had been removed. The explanation of non-union in these experiments seems to be non-apposition of fragment ends with removal of stress and strain, or incomplete immobilization (these animals were ambulatory and unsplinted), or the possibility of interposition of soft parts, or a combination of these factors. Microscopic studies of the cases in which non-union resulted showed fibrous tissue and muscle filling the defect between the bone ends. A gradual obliteration of the periosteal tube, largely by displaced or hypertrophied surrounding tissues, would be expected in the absence of ossification of the defect. Thus, it is not logical to attribute the non-union primarily to interposition of soft parts.

BONE ATROPHY

In the foregoing experiments that resulted in non-union, a progressive absorption of the fragment ends and a definite decrease in the roentgenographic density of the fibular fragments were seen. A concentric atrophy of the remaining fibular segments was marked in some cases. (See Figures 1-A and 1-B.)

Much has been written in regard to the causes and classification of bone atrophy. Acute post-traumatic bone atrophy was first described by Sudeck in 1900 and, as a result of his observations and more recently of those of Beck, Noble and Hauser, Fontaine and Herrmann, Gurd, and others, it is now accepted by many as a clinical entity. This is a relatively rare condition which follows either severe or relatively slight trauma, often to the ankle, wrist, or knee. Gurd, after a careful review of the literature and the study of his own fourteen cases, summarized the condition as follows: "Acute bone atrophy . . . exhibits typical clinical and radiological appearances. In a very small percentage of cases acute marked osteoporosis occurs within a short time following injury [usually a few days or weeks]. Pain is a predominant factor together with extreme loss of function. Swelling and evident atrophy of the skin and subcutaneous tissue are characteristically present. The condition follows, as a rule, more or less trivial injuries, particularly in the neighborhood of joints, and more especially in the neighborhood of ankle- and wrist-joints. Pathological studies prove a uniform loss of bony substance." Gurd also states that the "röntgenograms show a very typical patchy (*flächlich*) or 'moth-eaten' appearance of the bones in the immediate vicinity of the traumatized area and, also, in the bones distal to the region which has apparently been hurt". Sudeck in his later writings stated that he believed that the condition was due to a trophoneurotic phenomenon. Gurd, as well as Fontaine and Herrmann, considers that the condition is due to a stimulation of the reflex arc with consequent local hyperaemia,

producing bone absorption. These authors refer only to a change in local hyperaemia and do not distinguish between an active and passive hyperaemia, in which, at least in experimental studies, there is a difference both in blood chemistry (McMaster) and in the ability of bone to repair (Pearse and Morton, and McMaster and Roome).

ATROPHY OF DISUSE

Much clinical and experimental evidence has been accumulated to demonstrate that, when a part is put at rest, atrophy of bone occurs in direct proportion (up to reasonable limits) to the amount of disuse. Legg, in studying the cause of atrophy in joint disease, infected various joints in rabbits. He noted that the atrophy either from immobilization and infection or from immobilization alone was much greater than that from infection alone. In studying bone atrophy associated with both infected and non-infected fractures, Blake concluded that the degree of atrophy depends more on disuse than on infection. Likewise, Grey and Carr and Allison and Brooks demonstrated in rather extensive and conclusive experiments that bone atrophy definitely follows disuse. In their experiments on rabbits and dogs, one extremity was used for control; in the other, disuse was brought about by: (1) sectioning the motor nerves, (2) fixation in a plaster-of-Paris cast, and (3) resection of the proximal end of the humerus with a resultant flail joint. Grey and Carr also studied the effects of circulatory changes on the bony parts. They concluded that local venous congestion does not lead directly to any recognizable changes in the structure of bone and that local anaemia due to impairment of the arterial supply, unless it is extreme, likewise occasions no bone atrophy as long as the part remains functionally active. To study the effect of immobilization alone on bone atrophy in clinical cases, Key, Fischer, and Elzinga selected hospital patients and studied the effects of disuse brought about by the application of plaster-of-Paris casts on normal lower extremities. They found that immobilization with or without surgical intervention or manipulative procedures caused atrophy of the bones.

Murphy and Phemister showed that when bone is transplanted to muscle and to other soft parts, although the surrounding blood supply may be rich, the transplanted bone lacks the normal stimulus of function and is absorbed.

With the advent of non-union in the experiments outlined in this paper, the fibular fragments underwent atrophy of disuse, apparently from the lack of the normal stress and strain of weight-bearing and bony continuity, even though the fibula has little weight-bearing function. Muscle attachments were still present, and the bone atrophy indicates that an active circulation existed. These fragments seemed to be undergoing the same fate of returning to soft tissue as did the bone transplants of Murphy and Phemister. The atrophy did not follow plaster immobilization, as none was used; nor did inactivity of the limb influence the result,

for these animals were ambulatory and had the usual freedom of the laboratory.

Of especial interest is the fact that, of the ten animals in which non-union with associated atrophy occurred, eight exhibited bilateral absorption which was practically equal on the two sides despite the fact that operative procedures had been performed which caused a unilateral change in circulation. Two of these dogs had had unilateral femoral-vein ligation with its resultant passive hyperaemia, while six had had unilateral lumbar sympathectomy with its resultant arterial hyperaemia. Neither procedure occasioned any demonstrable difference in the bone atrophy. Hence the atrophy seems due specifically to disuse.

Microscopic studies of the atrophic fibular fragments revealed that in the most active areas bone was being destroyed by giant-cell osteoclastic lacunar absorption. (See Figures 4-A and 4-B.) In addition to this, there was a considerable amount of smooth and slightly serrated absorption produced by mononuclear cells. This was seen especially in the haversian and perforating canals containing blood vessels and fibrous marrow. Also cortical surfaces and fragment ends frequently showed a similar process without evidence of giant-cell osteoclasts, despite careful examination of numerous microscopic sections.

SUMMARY

1. The experimental evidence presented shows that in the presence of non-union of short fibular defects an associated conical bone atrophy, which in some cases was extreme, occurred in the fragment ends. The bone was removed both by lacunar absorption, produced by giant-cell osteoclasts, and by smooth absorption, produced by mononuclear cells. The atrophy is explained on the basis of disuse, caused by an interrupted bony continuity, which resulted in a lack of functional stimulus.

2. When atrophy and absorption of bone ends occurred it was bilateral in practically the same degree and rate despite the fact that on one side there was a circulatory change, produced either by lumbar sympathectomy or by vein ligation. Hence circulatory changes (arterial hyperaemia or venous congestion) *per se* had no essential effect on bone atrophy or on absorption.

3. Non-union occurred in seventeen of forty-four subperiosteal fibular defects (one and five-tenths millimeters), despite the presence in each case of an intact periosteal tube which bridged the defect. This failure of union is explained by non-apposition and excessive motion of the fragment ends, for in twenty-eight linear subperiosteal osteotomies in fibulae where the fragment ends were opposed only one case of non-union occurred.

REFERENCES

ALLISON, NATHANIEL, AND BROOKS, BARNEY: Bone Atrophy. An Experimental and Clinical Study of the Changes in Bone Which Result from Non-Use. Surg. Gynec. Obstet., XXXIII, 250, 1921.

ALLISON, NATHANIEL, AND BROOKS, BARNEY: Bone Atrophy: A Clinical Study of the Changes in Bone Which Result from Nonuse. Arch. Surg., V, 499, 1922.

BECK, OTTO: Die pathologische Anatomie und spezielle Pathologie der Knochenatrophie. Ergebn. d. Chir. u. Orthop., XVIII, 556, 1925.

BLAKE, J. A.: Repair of Bone Following Fractures. Arch. Surg., II, 37, 1921.

CAMPBELL, W. C.: Ununited Fractures. Arch. Surg., XXIV, 990, 1932.

FONTAINE, RENÉ, AND HERRMANN, L. G.: Post-Traumatic Painful Osteoporosis. Ann. Surg., XCVII, 26, 1933.

GREY, E. G., AND CARR, G. L.: An Experimental Study of the Factors Responsible for Non-Infectious Bone Atrophy. Johns Hopkins Hosp. Bull., XXVI, 381, 1915.

GURD, F. B.: Post-Traumatic Acute Bone Atrophy (Sudeck's Atrophy). Ann. Surg., XCIX, 449, 1934.

KEY, J. A., FISCHER, FREDERICK, AND ELZINGA, EUGENE: Local Atrophy of Bone. I. Effect of Immobilization and of Operative Procedures. Arch. Surg., XXVIII, 936, 1934.

LEGG, A. T.: The Cause of Atrophy in Joint Disease. Am. J. Orthop. Surg., VI, 84, Jan. 1908.

MCMASTER, P. E.: Peripheral Blood Chemistry Changes after Unilateral Lumbar Sympathectomy. Proc. Soc. Exper. Biol. and Med., XXX, 121, 1932.

MCMASTER, P. E., AND ROOME, N. W.: The Effect of Sympathectomy and of Venous Stasis on Bone Repair. An Experimental Study. J. Bone and Joint Surg., XVI, 365, Apr. 1934.

MURPHY, J. B.: Osteoplasty. Surg. Gynec. Obstet., XVI, 493, 1913.

NOBLE, T. P., AND HAUSER, E. D. W.: Acute Bone Atrophy. Arch. Surg., XII, 75, 1926.

NUTTER, J. A.: On Delayed Union and Non-Union of Fractures. J. Bone and Joint Surg., IV, 104, Jan. 1922.

OLLIER, LOUIS: Referred to by Sir Arthur Keith *in* Bone Growth and Bone Repair. Lecture III. Researches into Bone Growth and Bone Reproduction by Ollier of Lyons and Macewen of Glasgow. British J. Surg., VI, 160, 1918.

PEARSE, H. E., JR., AND MORTON, J. J.: The Influence of Alterations in the Circulation on the Repair of Bone. J. Bone and Joint Surg., XIII, 68, Jan. 1931.

PHEMISTER, D. B.: The Fate of Transplanted Bone and Regenerative Power of Its Various Constituents. Surg. Gynec. Obstet., XIX, 303, 1914.

STEINDLER, ARTHUR: A Textbook of Operative Orthopedics, Chap. IX. New York, D. Appleton & Co., 1925.

SUDECK, P.: Ueber die acute entzündliche Knochenatrophie. Arch. f. klin. Chir., LXII, 147, 1900.

Ueber die akute (trophoneurotische) Knochenatrophie nach Entzündungen und Traumen der Extremitäten. Deutsche. med. Wchnschr., XXVIII, 336, 1902.

SYME, JAMES: Referred to by Sir Arthur Keith *in* Bone Growth and Bone Repair. Lecture II. Researches made by Syme and by Goodsir Regarding the Growth and Repair of Bones. British J. Surg., VI, 19, 1918.

KÖHLER'S DISEASE OF THE TARSAL SCAPHOID

An End-Result Study

BY MEIER G. KARP, M.D., BOSTON, MASSACHUSETTS

From the Orthopaedic Service, Children's Hospital, Boston

This is an analysis of forty-five cases of Köhler's disease, treated at the Children's Hospital, Boston, during the past ten years. Roentgenograms showing complete healing and return to normal bone structure are available in nineteen cases.

An additional study has been made of the normal development of the scaphoid in roentgenograms, taken at six-month intervals, of children from nine months to four years of age.* Certain interesting facts were brought out in this study in relation to Köhler's disease.

Our data are not sufficiently complete to be presented in favor of a developmental etiology of Köhler's disease, although there is probably more to substantiate this theory than any of those that have been previously considered. However, certain clinical facts may be deduced from the tabulated data, and the diagnosis, prognosis, and treatment may be simplified.

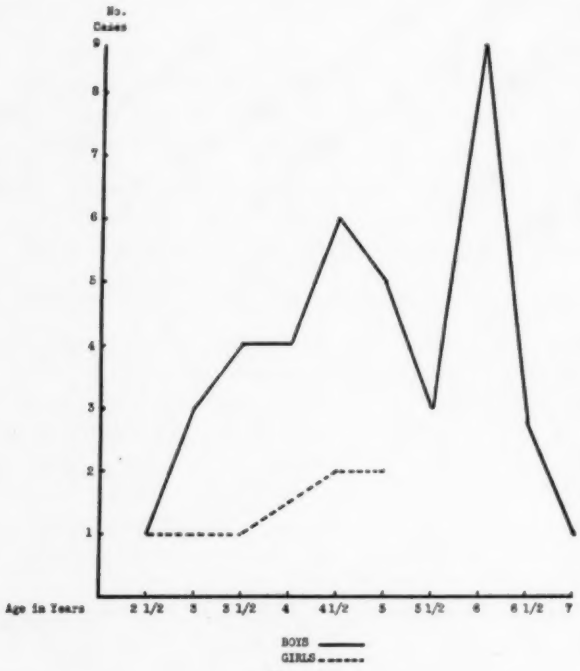


FIG. 1

Incidence of Köhler's disease at various age periods.

ANALYSIS OF DATA

In the present series, there were thirty-nine males and six females, a proportion of 6.5 to 1. The left foot alone was involved in twenty cases; the right, in sixteen; and there was bilateral involvement in nine. All of the bilateral cases were in males.

The age of the youngest patient was two years and six months and that of the oldest was seven

* These data have been made available through the courtesy of Miss Vickers of the Stuart Clinic which is studying the osseous development of normal children.

TABLE I

STATISTICAL ANALYSIS OF FORTY-FIVE CASES OF KÖHLER'S DISEASE

Sex Incidence:		
Females		6 cases
Males		39 cases
Age Incidence at Time of Diagnosis:		
Youngest		2 5/12 years
Oldest		7 5/12 years
Average		4 7/12 years
Involvement:	*Females*	*Males*
Left	4	16
Right	2	14
Bilateral	0	9
Symptoms:		
Definite		36 cases
None *		9 cases
Trauma:		
Definite history		14 cases
Questionable history		2 cases
No history		29 cases

* Condition accidentally discovered in the roentgenogram.

years and five months at the time of the first examination. The average age of onset was four years and seven months. The age incidence is shown in Figure 1.

Symptoms referable to the involved area were present in thirty-six cases. In nine cases there were no symptoms and the condition was accidentally discovered in studying roentgenograms taken for other purposes.

A definite history of antecedent trauma was elicited in only fourteen cases. Twenty-nine patients gave no history of trauma. In two cases trauma was questionable.

The duration of symptoms prior to first examination was extremely varied, ranging from a few days to a year, and appeared to have no relation to the character of the roentgenographic changes. Even in cases in which symptoms had been present for only a few days, the changes shown in the roentgenograms were obviously of longer duration.

Similarly, the duration of disability had no relation to the x-ray picture, and, with complete absence of symptoms, there were marked roentgenographic changes.

In nearly half of the cases roentgenographic studies showing regeneration of the scaphoid to normal are available. The period required varied from nine months to five years, the average being two and three-fourths years. Neither the character nor the duration of the treatment was a factor in the time required for regeneration of the bone to normal.

The usual early symptoms were *pain* accompanied by a *limp* on the

TABLE II

Complete Summary of Forty-Five Cases of Köhler's Disease

Case	Sex	Age at Onset (*Years*)	Duration of Symptoms Before Treatment	Trauma	Side	Early Symptoms	Type of Treatment
1. R. B.	Male	4 3/12	4 days	No	Left	Limp, inversion.	Pads, Thomas heels.
2. U. B.	Female	2 9/12	2 months	No	Right	Limp, tenderness.	Plaster, pads.
3. C. B.	Male	5 5/12	1 year	No	Bilateral	Pain, pronation.	Pads, exercises.
4. J. C.	Male	4 5/12	1 week	No	Bilateral	Pain, tenderness, pronation.	Pads, Thomas heels.
5. C. C.	Male	6	?	No	Right	None (accidental discovery).	None.
6. J. C.	Male	3 5/12	6 weeks	No	Left	Acute pain, swelling, limp.	Caliper, pads.
7. H. D.	Male	3	9 weeks	Yes	Right	Limp, pain, pronation.	Pads, Thomas heels.
8. G. D.	Male	7 5/12	4 months	No	Bilateral	None (accidental discovery).	Plates.
9. J. D.	Male	5 5/12	6 weeks	Yes	Right	Limp, swelling, pronation.	Pads, Thomas heels.
10. E. D.	Male	4 5/12	1 week	No	Bilateral	Limp, pain, pronation.	Pads, Thomas heels.
11. E. D.	Male	6 5/12	4 weeks	Yes	Bilateral	Limp (right).	Plates, pads.
12. D. G.	Male	4 5/12	4 months	No	Left	Pain, swelling, heat.	Incision and drainage by local doctor, pads.
13. L. G.	Male	6	?	No	Bilateral	Limp, pain, tenderness.	Weight-bearing restricted.
14. H. G.	Female	4 5/12	?	No	Left	Inversion.	Pads, Thomas heels.
15. P. G.	Male	4 5/12	1 month	Yes	Left	Limp, inversion.	Plaster, strapping, pads, Thomas heels.
16. J. H.	Male	5	5 months	Yes	Left	Swelling, tenderness, limp, pronation.	Hot soaks, adhesive, pads, Thomas heels.
17. J. K.	Male	6	?	Yes	Left (?) Right	Limp, pain, swelling.	Adhesive, non-weight-bearing.
18. D. K.	Male	2 5/12	?	No	Right	Pronation, high arch (no pain).	Pads.
19. M. L.	Male	3 3/12	?	No	Right	None (accidental discovery).	None.
20. P. L.	Male	4 5/12	1 week	No	Left	Swelling, heat, tenderness.	Pads, Thomas heels.
21. E. L.	Male	3 11/12	?	No	Right	None (accidental discovery).	None.
22. J. L.	Male	4 9/12	?	No	Right	None (accidental discovery).	None.
23. M. L.	Male	4 3/12	?	No	Left	Pain.	Pads, Thomas heels.
24. P. M.	Male	4 3/12	3 days	No	Left	Limp, pain, swelling.	Plaster cast.
25. A. M.	Male	4 5/12	1 month	Yes	Right	Limp, eversion, pronation.	Pads, Thomas heels.
26. A. M.	Male	6 5/12	5 months	Yes	Bilateral	Pain, swelling, heat.	Pads, Thomas heels.
27. F. M.	Male	6 5/12	4 months	No	Left	Swelling, tenderness.	Adhesive strapping.
28. E. M.	Male	5 3/12	2 weeks	No	Right	None (accidental discovery).	None.
29. E. N.	Male	3 5/12	?	No	Right	None (accidental discovery).	None.
30. R. N.	Male	6 5/12	5 months	Yes	Right	Limp, heat, tenderness.	Plaster, pads, Thomas heels.
31. A. P.	Male	5 3/12	2 weeks	No	Left	Swelling, pronation.	Pads, Thomas heels.
32. F. R.	Female	4 5/12	1 month	No	Left	Limp, tenderness, swelling.	Plaster cast.
33. A. S.	Male	6 5/12	4 days	Yes	Bilateral	Tenderness, pronation.	Pads, Thomas heels.
34. J. S.	Male	3 1/12	7 months	No	Bilateral	Limp on left (no pain).	Adhesive strapping, pads, Thomas heels.
35. T. S.	Male	3 5/12	2 days	No	Left	None (accidental discovery).	Pads, Thomas heels, limitation of weight-bearing.
36. C. S.	Female	3 11/12	3 weeks	Yes	Left	Pronation, swelling, oedema.	Adhesive, plaster, pads, Thomas heels.
37. D. S.	Female	5 5/12	2 weeks	No	Left	Swelling, heat, tenderness.	Adhesive, pads, Thomas heels.
38. J. S.	Male	6	1 week	?	Left	Inversion, swelling, heat.	Pads, Thomas heels.
39. R. S.	Male	5 5/12		No	Left	None (accidental discovery).	None.
40. R. T.	Male	6 3/12	6 months	?	Left	Swelling, limp.	Pads, Thomas heels.
41. E. T.	Female	5 5/12	3 months	Yes	Right	Limp.	Pads, Thomas heels, plates.
42. A. V.	Male	5	3 weeks	Yes	Right	Limp, swelling, tenderness.	
43. K. W.	Male	3 5/12	3 weeks	No	Right	None (accidental discovery).	None.
44. R. W.	Male	5 5/12	5 days	No	Left	Limp, tenderness.	Adhesive, pads, Thomas heels.
45. V. W.	Male	3 5/12	4 days	Yes	Left	Limp, pain.	Plaster casts.

TABLE II (*Continued*)

COMPLETE SUMMARY OF FORTY-FIVE CASES OF KÖHLER'S DISEASE

Duration of Treatment	Duration of Disability	Roentgenographic Appearance of Scaphoid	Duration of Recovery to Normal as Indicated by the X-Ray	End Result
6 months	3 weeks	First x-rays lost.	5 years	Pronation, cavus; scaphoid regenerated to normal.
3 years	?	Flat, of increased density.	2½ years	Feet normal; scaphoid normal.
1 year	?	Flat, fragmented; 2 centers of ossification.		Normal feet; prominent dorsum, flexible, high arch.
?	3 weeks	Left: small, flat, dense. Both: several ossification centers.		
None	None	Typical.*		
4 years	1 year	Small, normal density. Later, fragmented and destroyed.	4 years	Scaphoid normal; mild pronation, feet otherwise normal.
3 months	3 months	Small, flat, dense. Later, typical.		
?	None	Irregular, fragmented, dense.		Pronation, good arch.
2¾ years	1 year	Typical.	6 11/12 years	Scaphoid normal; pronation, flat feet.
?	?	Typical.		
8 months	3 months	Two centers of ossification; irregular, dense.	1 11/12 (not quite normal)	High arch, no pronation, prominent dorsum.
	2 months	Typical.		
?	?	Typical.		
1½ years	?	Small, irregular, dense.	1½ years	Scaphoid regenerated to normal.
8 weeks	6 weeks	Typical.		
?	?	Flat, dense.	3 years	Scaphoid normal; feet normal.
?	?	Small, narrowed, normal density and outline.		
3 years	2 weeks	Small, dense, narrowed.	9 months (almost normal)	Narrow feet, no pronation; scaphoid normal; dorsum prominent and long.
None	None	Typical.		
?	1 month	Typical; no fragmentation.		
None	None	Typical.		
None	None	Typical.		
6 months	?	Typical; 2 ossification centers.		
1 month	1 month	Typical.		
4 years	1 week	Typical.	5 years	Scaphoid normal; marked pronation.
22 months	5 months	Typical.	2 years	
1 year	2 months	Typical.		
None	None	Typical.	4 11/12 years	Scaphoid regenerated to normal.
None	None	Typical.	3 years	Scaphoid normal; pronation.
2 years	10 months	Typical.	1 11/12 years	Scaphoid regenerated to normal.
		Typical; 2 centers of ossification.		
4 months	2 months	Typical.		
2 years	A few days	Typical.	2 11/12 years	Scaphoid normal; pronation, broad feet, prominent dorsum.
2½ years	6 months	Typical.	2 11/12 years	Scaphoid normal; pronation.
		Typical.	1 year	Scaphoid regenerated to normal.
1½ years	15 months	Small, irregular, mottled.		
		Typical.	9 months	Scaphoid regenerated to normal.
7 months	4 months	Typical; 2 fragments.		
None	None	Typical.		
2½ years	5 months	Typical.	2 11/12 years	Scaphoid regenerated to normal.
4 years		Typical.	3 11/12 years	Scaphoid regenerated to normal.
		Typical.		
None		Small, fragmented; 2 centers of ossification.		
?	1 month	Typical.		
?	1½ years	Typical.	3 11/12 years	Scaphoid normal; pronation, prominent dorsum.

* Typical = flat, increased density, irregular in outline.

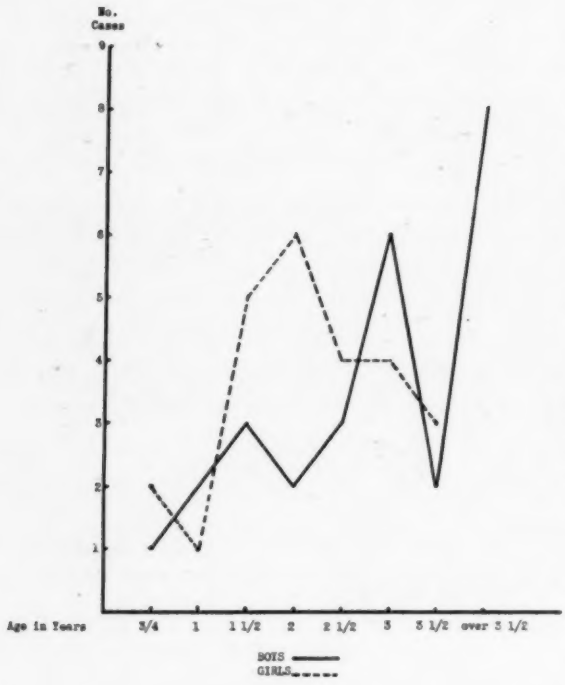


FIG. 2

Normal development of scaphoid at various age periods.

affected side, with localized tenderness and *swelling* over the dorsum of the foot. In many cases redness and local heat were present, suggesting an infectious process, and in two cases incision and drainage had been done by the attending physician prior to examination at the Children's Hospital. The foot was held in moderate *pronation* in most cases; occasionally it was found to be in the position of *inversion*.

The treatment varied according to the judgment of the attending surgeon, but the end result was the same, regardless of the type of treatment or of the absence of treatment. With restriction of weight-bearing, symptoms subsided promptly, following which activity was instituted, with a felt pad and a Thomas heel for support. Plaster casts, adhesive strapping, hot soaks, caliper splints, etc., were used at times, but such treatment did not materially influence either the course of the disease, or the duration of the disability, or the end result. Recurrence of the pain and the limp was not infrequent during the course of the treatment, but took place as frequently in the patients wearing foot supports as in the untreated patients. In one case pain recurred even after the roentgenogram showed complete regeneration of the scaphoid.

A description of the foot after complete regeneration of the scaphoid was obtained in fourteen cases. These were all normal feet, varying from a typically flat, pronated foot to a high-arched, prominent-dorsum type of foot,—all excellent weight-bearing extremities. In no instance has disability resulted, and none of the feet are "deformed".

NORMAL DEVELOPMENT OF THE TARSAL SCAPHOID

The roentgenograms of fifty normal children, taken during the age period when the scaphoid develops, were examined. There were twenty-five boys and twenty-five girls in this series. These children were all born at full term with normal deliveries. Roentgenograms

Left Right

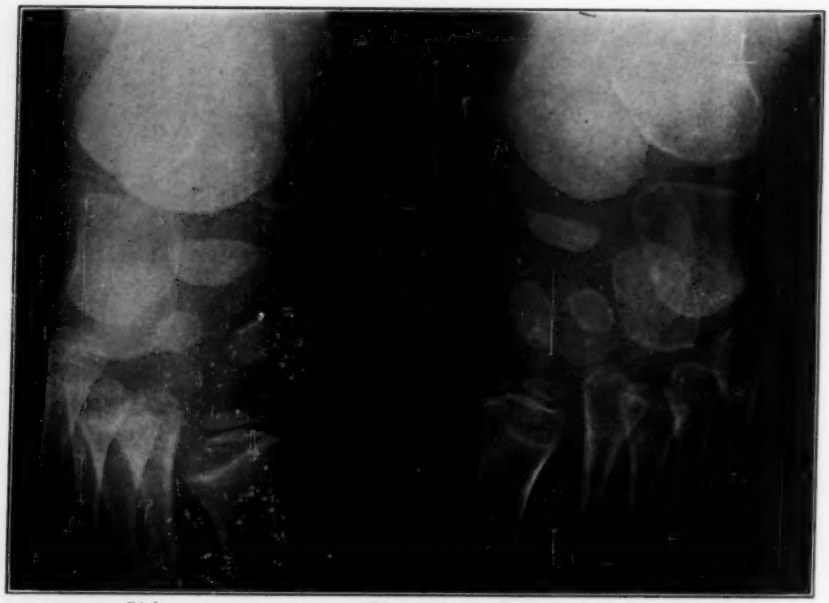
FIG. 3

Lateral roentgenograms of both feet of a boy, aged six and one-half years. The right foot shows typical Köhler's disease. The left scaphoid is slightly irregular, but normal in density. However, there were symptoms referable to both feet, and pain persisted much longer on the left side than on the right.

FIG. 4-A

FIG. 4-B

Same case as shown in Fig. 3. Roentgenograms of the right foot, taken eight months (Fig. 4-A) and eighteen months (Fig. 4-B) later than Fig. 3. Note the increased fragmentation in Fig. 4-A, followed by return to normal density in Fig. 4-B. The outline is still slightly irregular.



Right FIG. 5-A Left

July 10, 1929. Anteroposterior roentgenograms of both feet of a boy, aged three years and nine months, showing the left scaphoid to be smaller than the right, but of normal outline and density. There is marked swelling of the soft tissues and bone atrophy.

In this case there was a history of an acute onset of swelling, pain, and heat in the left foot. An incision was made; the area drained and healed quickly; and the child was walking in three weeks.

Right FIG. 5-B Left

Roentgenograms, taken September 21, 1929, showing the left scaphoid to have almost entirely disappeared, as a result of the infection, in spite of its short duration. Repeated tuberculin tests were negative.

FIG. 6-A
February 8, 1930.

FIG. 6-B
June 7, 1930.

FIG. 6-C
February 14, 1931.

FIG. 6-D
February 3, 1932.

Same case as in Figs. 5-A and 5-B, showing the regeneration of the scaphoid in the left foot, over a period of two and one-half years following the onset. This may not be a case of Köhler's disease, although the short duration of drainage and disability is certainly atypical of a bone infection and the manner in which the scaphoid regenerated is very similar to that seen in Köhler's disease.

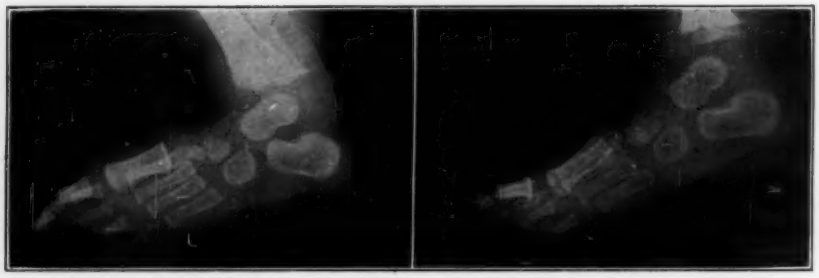


FIG. 7-A
Six months.

FIG. 7-B
Nine months.

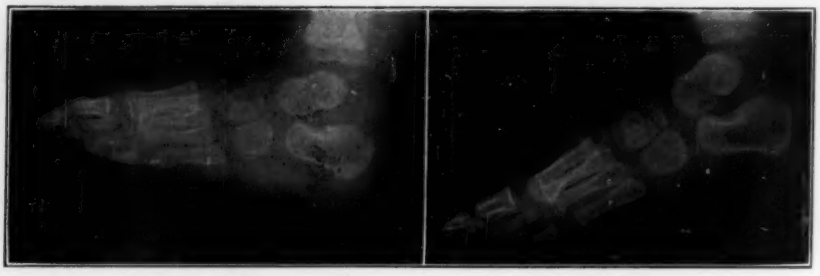


FIG. 7-C
Twelve months.

FIG. 7-D
Eighteen months.

Lateral roentgenograms of the right foot of a girl, showing development in first eighteen months. At the age of six months, no scaphoid is visible; at nine months, a tiny osseous nucleus is present; and, at twelve and eighteen months, the scaphoid is well formed and normal in outline and density. This may be considered a case of accelerated development of the scaphoid.

were made beginning at nine months and ending at four and one-half years of age.

In this study it was possible to determine the earliest appearance of the osseous nucleus of the scaphoid, and to note its rate of development and its appearance at various ages.

Figure 2 shows that the scaphoid makes its appearance much earlier in girls than in boys. More than half the girls (fourteen cases) had a well-developed osseous nucleus at two years of age, and in all the cases the scaphoid could be seen at three and one-half years of age. Osseous nuclei were observed as early as nine months in girls.

The boys, on the other hand, were markedly retarded. It required three years for the same number of patients to show an osseous nucleus, and more than one-third of the boys were over three and one-half years old before the scaphoid appeared. Even at that age, in many of these cases, no scaphoid could be seen.

The average age for the appearance of osseous nuclei in the roentgenogram may be considered to be between eighteen months and two years in girls, and between two and one-half and three years in boys.

In following the development of the scaphoid in periodic roentgenograms, the shape, outline, and density of the bone were found to be related

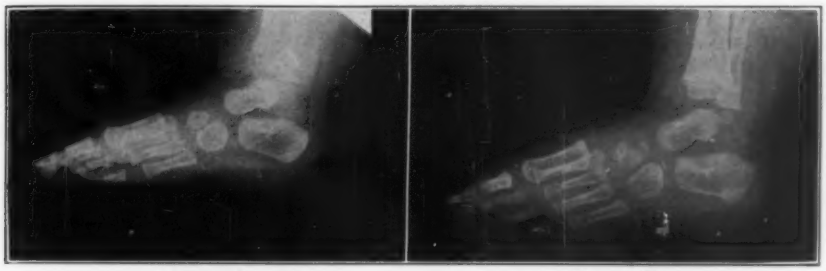


FIG. 8-A
Twelve months.

FIG. 8-B
Eighteen months.

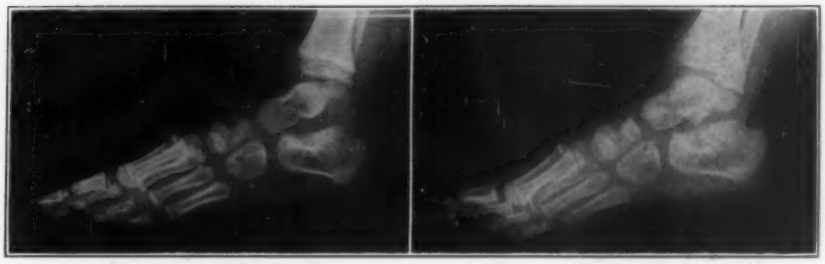


FIG. 8-C
Twenty-four months.

FIG. 8-D
Thirty months.

Roentgenograms of the right foot of a girl, taken at twelve, eighteen, twenty-four, and thirty months. In this case, the scaphoid appears at eighteen months, which is average for a girl, and in its later development is smooth in outline and of normal density.

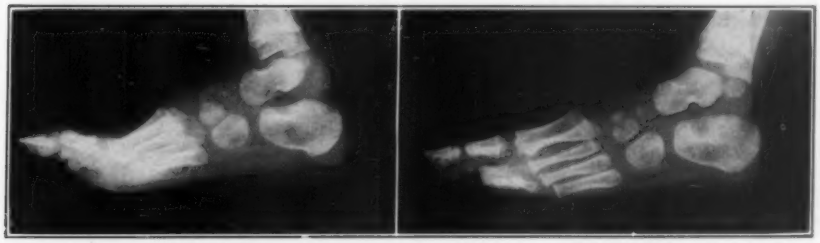


FIG. 9-A
Two and one-half years.

FIG. 9-B
Three years.

FIG. 9-C
Three and one-half years.

FIG. 9-D
Four years.

Roentgenograms of the right foot of a girl, taken at two and one-half, three, three and one-half, and four years. In this case, the scaphoid appears at three years, which is retarded for a girl, and in its later development is quite irregular in outline, somewhat fragmented, and of slightly increased density,—a picture not dissimilar to that seen in Köhler's disease.

FIG. 10-A
Six months.

FIG. 10-B
Nine months.

FIG. 10-C
Twelve months.

FIG. 10-D
Eighteen months.

Roentgenograms of the right foot of a boy, taken at six, nine, twelve, and eighteen months. In this case the scaphoid first appears at nine months, which is quite accelerated for a boy, and in its subsequent development preserves a smooth outline and a normal density.

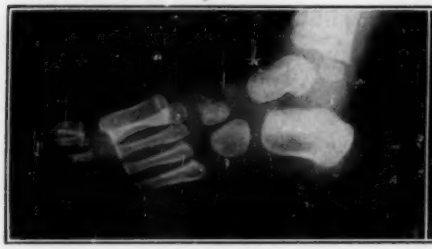


FIG. 11-A
Two years.

FIG. 11-B
Two and one-half years.

FIG. 11-C
Three years.

FIG. 11-D
Three and one-half years.

Roentgenograms of the right foot of a boy, taken at two, two and one-half, three, and three and one-half years. In this case the scaphoid first appears at two and one-half years, which is average for a boy, and at three and one-half years is of normal outline and density.

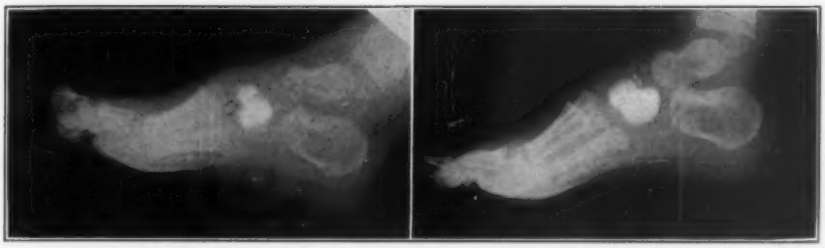


FIG. 12-A
Two and one-half years.

FIG. 12-B
Three years.

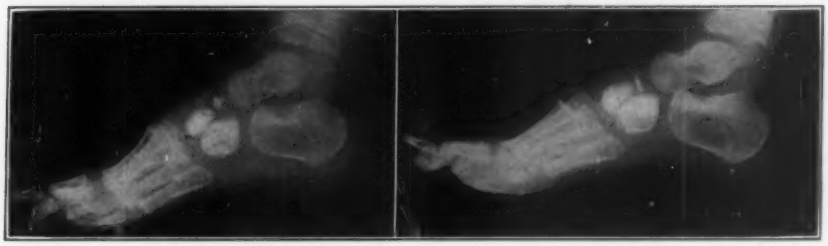


FIG. 12-C
Three and one-half years.

FIG. 12-D
Four years.

Roentgenograms of the right foot of a boy, taken at two and one-half, three, three and one-half, and four years. In this case, the scaphoid first appears at three years and, although of normal outline at three and one-half years, it becomes quite flattened, lozenge-shaped, and definitely increased in density at four years. At this age, the roentgenogram is very similar in appearance to that seen in Köhler's disease.

to the time of appearance of the osseous nucleus. The accelerated and normal-time scaphoids preserved a smooth outline, a rounded shape, and a uniform density; the retarded scaphoid, on the other hand, was very often irregular in outline, of increased density, and flattened or even fragmented in shape,—a picture often identical to that seen in Köhler's disease. Frequently several osseous nuclei appeared together and their eventual coalescence resulted in an extremely unusual configuration. This was never observed in the accelerated scaphoid and infrequently in the normal-time scaphoid. So often did this type of development occur that it would seem to be more than a chance finding. There appears to be a relationship between the time of appearance of an osseous nucleus, its configuration, and its density.

The only other tarsal bone which showed an analogous picture was the middle cuneiform, which usually appears at the same time or later than the scaphoid. No definite study of its development was made, but, when retarded in development, its configuration was often quite irregular.

It was not possible to determine the time required for these irregular nuclei to assume a normal contour inasmuch as the children studied are now only four years of age. Obviously, there was a much higher incidence of abnormal development of the scaphoid in boys than in girls, because of the retarded development of the osseous nucleus in boys as com-

pared with that of girls. When one compares this with the much higher incidence of Köhler's disease in boys than in girls, the figures take on an added significance.

A series of roentgenograms are included to show the characteristics of the accelerated, normal, and retarded scaphoids in both boys and girls.

SUMMARY

This syndrome occurs predominantly in male children between the ages of two and one-half and seven and one-half years, and is manifested by pain, a limp, swelling, and localized tenderness in the foot. It is more frequently unilateral than bilateral and has a characteristic x-ray picture which is unrelated to duration of symptoms or to treatment. Complete regeneration of the involved bone takes place in an average of two and three-fourths years, and a normal foot is the usual end result.

It is suggested by this study that the retarded development of the osseous nucleus of the scaphoid may alter its density, outline, and configuration, so as to simulate the picture of Köhler's disease.

EPIPHYSIOLYSIS OR EPIPHYSEAL COXA ANTEVERTA *

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

Associate Attending Orthopaedic Surgeon, Hospital for Joint Diseases †

During the past fifty or sixty years, much has been written upon the condition which is now commonly designated as epiphysiolysis, epiphyseal coxa vara, or displacement of the upper femoral epiphysis in adolescence. Practically all of the known information up to 1926 was collated in a classic article by Key. Since that time a number of other articles, dealing with special aspects of the condition, have appeared. Although the clinical picture has been delineated in considerable detail, there is still no accurate knowledge of its ultimate etiology, of its pathogenesis, or, indeed, of its treatment. In regard to this latter problem, a wide diversity of opinion exists,—radical excision or open reduction with subsequent nailing of the slipped capital epiphysis, drilling across the epiphyseal line, impaction by the Cotton mallet, and manipulation with or without the use of a brace or a plaster spica have all in turn been advocated. MacAusland, Pomeranz and Sloane, and others have attempted to come to a conclusion upon this very vital matter of therapy. It would appear from their writings that, as between the surgical and the non-surgical methods of treatment, the balance is by all means on the side of the latter.

Even in the cases conservatively treated, however, a great variation in results has been noted. Some cases gave "excellent" results and others gave "satisfactory" results, and the outcome appeared to be a matter of chance. It was because of this that the author's interest in the subject was aroused. As a matter of fact, it was the study of Case 1, in which the result was considered "satisfactory", that led to the present essay. As this case and others were studied, it was discovered that the observations made were typical of all cases of epiphysiolysis. It was then realized that the explanation of the variation in results could be attributed to an erroneous appraisal of the disease, and that the new conception, achieved as a result of the present study, would be of value in forming the basis for a better understanding and a more rational therapy of the condition. In this preliminary report an attempt will be made to present the general clinical and roentgenographic data. The more detailed study of the roentgenograms and the therapeutic consequences of the present pathogenetic concept will be reported in other communications which are now being prepared.

CASE 1. I. H., a girl, aged eleven years, was first seen on May 13, 1935. While playing ball some six days before, she had suddenly complained of pain in the right hip, which became so severe that she was confined to her bed. Because of this, the child was brought to the Hospital.

* Received for publication, May 1, 1936.

† From the Service of Harry Finkelstein, M.D.

It was observed that the length from the right anterior superior spine was twenty-nine and three-quarters inches and that from the left was thirty inches. The right leg was held in flexion and external rotation. All motions of the hip were resisted because of pain. An x-ray (Fig. 1-A), taken the following day, disclosed "complete separation of the capital epiphysis with downward and inward displacement of the epiphysis, associated with slight posterior rotation of the part".

FIG. 1-A

Case 1. May 14, 1935. Stage of fracture. The shaft is displaced upward and rotated externally. The upper end of the neck is anteverted. The capital epiphysis, of normal height, lies in the acetabulum. The larger arrow points to the tip of the greater trochanter, the smaller arrow to the upper rim of the anteverted neck of the femur.

The patient was consequently anaesthetized and the upward dislocation of the shaft was overcome. A roentgenogram (Fig. 1-B), taken on May 16, 1935, was reported as showing "overcorrection, the superior aspect of the head being one-half an inch above the level of the superior border of the neck". This was subsequently corrected, since a roentgenogram, taken through a heavy plaster spica on May 22, 1935, was reported as showing "good alignment of the capital epiphysis" and reduction of the overcorrection. The patient was discharged, wearing a large plaster-of-Paris spica.

On August 26, 1935, another roentgenogram (Fig. 1-C) was taken, which showed the epiphysiolysis previously noted. The report further

FIG. 1-B

Case 1. May 16, 1935. The varus has been overcorrected. The head is of normal height. The arrow points to the lower rim of the subcapital shadow which represents an oblique end-on view of the partly anteverted proximal end of the femoral neck.

FIG. 1-C

Case 1. August 26, 1935. This view is part of a stereoscopic roentgenogram. It explains the foreshortening of the capital epiphysis which has united to the femoral neck and has, therefore, rotated with it. The large arrow points to the lower edge of the capital shadow. The small arrow points to the edge of the subcapital shadow. Both could be seen in the roentgenogram taken in May through the plaster spica.

stated: "No alteration in the position of the capital epiphysis and neck of the femur as compared with hospital plates of May 22, 1935. Epiphyseal line almost completely obliterated." To prevent the possibility of any sudden fall, the patient was fitted with a Thomas walking hip splint.

Up to the time when this paper was written, the right hip remained free from any symptoms, although complete restoration of normal joint function had by no means been achieved. Repeated examinations revealed a definite limitation of motion in the following sense:

	Right (Affected) *Degrees*	Left (Normal) *Degrees*
Angle of flexion (line of the trunk being 0 degrees)	85	135
Angle of internal rotation (neutral position being 0 degrees)	10	35
Angle of abduction (pelvis level, line parallel to midline being 0 degrees)	25	45

FIG. 2-A

Case 1. Lateral view, showing the anterior displacement of the head.

FIG. 2-B

Case 1. Anteroposterior view, with the leg in marked external rotation. Contrary to what is seen in the early stages of the disease, the subcapital shadow has disappeared, while the head has regained its normal height, as compared with Fig. 2-C. This paradoxical appearance is characteristic of the stage of malunion. The disappearance of the subcapital shadow can only be explained on the ground that it is cast upon the shadow of the whole length of the neck and so becomes invisible.

FIG. 2-C

Case 1. Anteroposterior view, with the leg in internal rotation of 35 degrees. Note that the subcapital shadow thrown by the femoral neck is concurrent in its lower portion with the lower part of the shadow thrown by the capital epiphysis. Because of the fact that union has taken place, the capital epiphysis has rotated and is foreshortened.

FIG. 3-A

Anteroposterior view of the hip of a normal twelve-year-old child.

Moreover, when the whole series of roentgenograms were again carefully reviewed, it was observed that, even after the so called satisfactory reduction of the slipped epiphysis, a peculiar elliptical shadow, not normally seen, was found just beneath the capital epiphysis. With the object of elucidating the significance of this shadow, a number of different x-ray exposures of the affected hip were made. Dr. Pomeranz reported on the stereoscopic plates as follows: "The width of the capital femoral epiphysis is distinctly reduced and it appears to be rotated so that its articular surface faces backward and inward. The femoral neck is anteverted, so that a considerable area of its posterior surface is in contact with the epiphyseal-plate surface of the femoral head. Therefore, the femoral neck is seen end on and facing forward. Several concentric lines are seen and their significance is appreciated only on stereoscopic vision. The outermost line represents the anterior rim of the femoral neck which has been rotated outward. The second, and somewhat indistinct line, represents the posterior lip of the epiphyseal-plate surface of the femoral head, whose shadow is projected behind the neck. The third concentric density is easily identified as the anterior rim of the epiphyseal-plate surface of the femoral head which has been rotated internally. Roentgenographically, it is evident that the coxa-vara deformity is corrected, but that the anteversion of the femoral neck persists."

As an additional check upon these findings, the hip was rotated externally 90 degrees and abducted to 90 degrees, so that a lateral view of the head and neck was obtained (Fig. 2-A). Roentgenograms were then made with the hip in 35 degrees of internal rotation (Fig. 2-C) and in 75 degrees of external rotation (Fig. 2-B) and these were compared with controls of a relatively normal hip taken in corresponding positions (Figs. 3-A, 3-B, and 3-C). All of these roentgenograms confirmed the impression that the leg had rotated externally, so that the proximal end of the femoral neck pointed forward and was not covered by the head. The head, while still in the acetabulum, was in contact with the back of the femoral neck. However, instead of lying in the axis of the neck, the head formed with the neck an angle, the apex of which in the coronal plane pointed forward and outward. Since, upon internal or external rotation of the leg, there was no change in the relationship between head and neck, it was felt that the roentgenograms represented a terminal or healing stage of the condition.*

As this series of roentgenograms and, later, other series were studied again and again, several interesting observations were made. It was seen that a very considerable degree of anterior displacement of the capital epiphysis may be demonstrated by lateral or by stereoscopic roentgeno-

* This patient subsequently developed an acute epiphysiolysis of the left hip. Since this occurred later in the chronological development of this new conception, and since the treatment instituted was a direct consequence of the idea, the further consideration of this case, especially as regards the left hip, will best be deferred until somewhat later in this communication.

FIG. 3-B

Anteroposterior view, with the leg in external rotation. Note that the epiphyseal line can still be recognized. The large shadow thrown by the capital epiphysis is indicated by the arrow. No subcapital shadow is visible. The head is of normal height.

FIG. 3-C

Anteroposterior view, with the leg in internal rotation. The epiphyseal line can be seen. The circular shadow of the head has disappeared. There is no subcapital shadow. The head is of normal height.

grams (Fig. 1-C), even though it may have been entirely unsuspected from a study of the simple flat plate. It was noted further that simple traction or manipulation for the correction of the varus deformity, due to the upward riding of the shaft of the femur in relation to the head, did not seem to insure anything more than a "satisfactory result". Even in those cases in which the varus was completely corrected, there still remained limitation of motion and roentgenographic evidence of an abnormal subcapital shadow which was not seen in any position of internal or external rotation of the normal hip. While these facts were being considered, the idea suddenly presented itself that the neglected factor, the missing link, in the rational explanation and therapy of epiphysiolysis lay in the anteversion of the neck of the femur.

The more this possibility was contemplated, the more beautifully it seemed to harmonize with the details of the clinical picture of epiphysiolysis. It emphasized the significance of external rotation in precipitating the actual slipping, and it accounted for the fact that eversion of the leg was among the earliest of the clinical symptoms. Moreover, it explained the peculiar subcapital shadow and the fact that in operated cases in which similar x-ray findings had been noted, and in which care had been taken to describe the relationship between the head and the femoral neck it had

been observed invariably that the neck pointed forward and the head was posterior to the plane of the femoral neck, or that head and neck had united so as to form an angle whose apex was forward. In order to establish this premise on a firm basis, it was felt that the early stages of the disease must be studied and that, if possible, the roentgenographic evidence of the condition should be reproduced under the control of the eye.

FIG. 4-A

Case 2. February 4, 1936. Anteroposterior view, showing the "preslipped" stage. Note widening of the epiphyseal line.

The former condition was fulfilled with little difficulty, since by good fortune several early cases came to hand shortly afterward. All showed in the early stages the so-called widening of the epiphyseal line which has been considered as pathognomonic of epiphysiolysis. Apart from this, the flat plate in the anteroposterior plane showed no slipping. It was only when lateral views of the head and neck were made that it was observed that even the early stages were characterized by an anteversion

FIG. 4-B

Case 2. Lateral view; slipping has occurred, but in the anteroposterior plane. This is the stage of moderately advanced anteversion.

FIG. 4-C

Anteroposterior view, taken a week later than Fig. 4-B, showing the characteristic upward slipping.

of the neck, which seemed to become more marked with the increase in the widening of the epiphyseal line. This is quite well shown in the following case which may be considered as typical.

CASE 2. H. H., a girl, aged ten years, was admitted to the Hospital on February 10, 1936, from the Out-Patient Department of the Good Samaritan Dispensary, where she had been under the observation of Dr. Tunick. The patient had been seen some two weeks before, when she complained of pain in the left hip, accompanied by a limp. Weight was sustained on the right leg. The left leg was externally rotated, the gluteal fold being lower than on the right side. A roentgenogram (Fig. 4-A), taken on February 4, 1936, showed the typical picture of a "widened epiphyseal line". There seemed to be good alignment of the head and neck in the coronal plane. It was only when a true lateral exposure (Fig. 4-B) was made by abducting and externally rotating the thigh that it was realized that in relation to the femoral head there was a marked forward displacement of the neck in a sagittal plane.

A week later actual upward "slipping" occurred. The trochanter rose above Nelaton's line, and there was limitation of abduction and of internal rotation. Definite shortening was noted,—the length from the right anterior superior spine was thirty and three-quarters inches, while that from the left was thirty and one-quarter inches. A roentgenogram (Fig. 4-C), taken at this time, showed a typical coxa vara on the flat plate. The condition was corrected by means of abduction and slight internal rotation, but a roentgenogram, taken through the plaster, revealed a subcapital shadow similar to that seen in Figure 1-C. Further correction of the deformity by means of marked internal rotation was recommended, but was refused. Although it is the author's opinion that this patient will display the same order of limitation of motion as was noted in the right hip in Case 1, it is still too early to determine this with accuracy.

The series of cases, of which the above is typical, served to illustrate the fact that the anteversion of the neck antedated the varus and that the correction of the one deformity in no way predicated even an amelioration of the other. They served further to call attention to the fact that anteversion of the neck seemed to be related to the peculiar subcapital shadow which was constantly seen in cases inadequately reduced. It became important, therefore, to determine the significance of this subcapital shadow—the second of the conditions previously mentioned. Ideally, the hip of an adolescent child should have been used for the purpose of experimentation, but, in spite of repeated attempts, all efforts to secure such a specimen, even from the City morgue, were in vain. In lieu of this, it was decided to use the hip of a three-year-old monkey (rhesus).* With the exception of some slight anatomical variations, the hip of this monkey may be accepted as the equivalent of the adolescent human hip.

The pelvis was first x-rayed to insure the patency of the epiphyseal line. (See Figure 5-A.) The epiphysis was then separated from the neck and replaced upon the upper posterior rim of the neck of the femur in such positions that the roentgenograms might be expected to resemble those seen in human epiphysiolysis. Some difficulty was experienced in maintaining the neck against the capital epiphysis, because of the shortness of the neck and the excessive size of the head. While the roentgenograms were not as typical as it is possible to make them, it was felt that they were

* For this privilege the author is indebted to Prof. E. T. Engle, of the Department of Anatomy at the Columbia University College of Physicians and Surgeons.

FIG. 5-A

FIG. 5-B

FIG. 5-C

FIG. 5-D

FIG. 5-E

FIG. 5-F

FIG. 5-G

Fig. 5-A: Normal female monkey (rhesus), three years old.

Fig. 5-B: Anteroposterior view, after separation at the epiphyseal line. The leg is externally rotated about 45 degrees. The head has been rotated backward. Note the foreshortening of the head and the subcapital shadow which is manifestly due to the upper end of the anteverted femoral neck.

Fig. 5-C: Anteroposterior view, after external rotation of the leg to 60 degrees. The steel needle has been inserted perpendicular to the center of the surface of the upper end of the neck. The head has been so placed as to show its normal height. Note that in all views the head remains in the acetabulum.

Fig. 5-D: Anteroposterior view with the leg in 45 degrees of external rotation. The subcapital shadow which is clearly seen in Fig. 5-F, when the head was removed, is obviously cast only by the upper end of the femoral neck.

Fig. 5-E: Note the increase in the subcapital shadow with increase in external rotation.

Fig. 5-F: The same view as Fig. 5-D, showing the femur with the head removed.

Fig. 5-G: The same view as Fig. 5-E, showing the femur with the head removed.

sufficiently suggestive to warrant reproduction. Figure 5-B shows the apparent decrease in the height of the capital epiphysis which was noted when the whole extremity was placed in the neutral position after the shaft of the femur had been externally rotated 45 degrees in relation to the capital epiphysis. Figure 5-C shows the increase in the height of the capital epiphysis and the "widening of the epiphyseal line", which occurred on externally rotating the shaft 60 degrees in relation to the head. During all of the manoeuvers which were undertaken, the head remained within the acetabular cavity regardless of the apparent size of the capital epiphysis. In other words, slipping of the capital epiphysis did not occur at all. The changes which were noted in the size of the head in the roentgenogram were not real but apparent, and were due to foreshortening of the head as a consequence of internal or of external rotation. The only "slipping" which did take place was a rotation,—an anteversion of the upper end of the femoral neck beneath the epiphyseal plate of the head. As this anteversion of the neck was gradually increased, so that more and still more of the upper end of the neck became visible, it was noted that the roentgenogram showed a corresponding change in the subcapital shadow. From being a small subcapital ellipse, it gradually increased in diameter until complete anteversion revealed a circular shadow, resembling fairly accurately that seen in Figure 1-C. In order to eliminate any extraneous elements, the femur was exarticulated and roentgenograms were made of its upper end as the neck was progressively anteverted. Some of these exposures (Figs. 5-D and 5-E) were made with the head *in situ* and others (Figs. 5-F and 5-G) with the head removed. As before, it was seen that, with increasing anteversion of the neck, the shadow of the epiphysis changed from an irregular line into a narrow ellipse. This gradually increased until a complete circle presented beneath the head when the neck pointed directly forward. It was apparent that these represented the shadows which were thrown by the proximal surface of the neck of the femur and which were seen first in profile and later end on.

This situation was readily comprehended as the visual expression of a fundamental proposition in projective geometry. The changing shadows represented the various projections of the roughly circular upper end of the femoral neck when exposed to the bundle of x-rays at angles varying from complete parallelism to complete perpendicularity. Once this was clearly established, it was apparent that the double shadow, observed in the roentgenograms of the monkey and of the children, was caused by the projection of two separate structures,—the upper end of the femoral neck and the lower or inferior surface of the capital epiphysis. The former cast the subcapital shadow; the latter, the capital shadow. For the purpose of calling to mind graphically the relationship which exists between the head and the neck of the femur, the acorn may be used as an example. The cup of the acorn represents the head, and that portion of the nut which fits into and is covered by the cup represents the upper end of the femoral neck. The circumference of each forms roughly a circular outline which

is in the main concurrent, and which will cast a single shadow as long as both parts are in contact. However, when this fixed relationship is modified, so that the two circumferences are no longer concurrent—when the nut rotates out of the cup—it follows that the shadows cast by each will be independent and will vary in a manner depending upon the angle at which each circumference intercepts the bundle of rays. This is exactly the situation in the condition of epiphysiolysis. As long as the head is firmly fixed to the neck, both cast a single shadow, regardless of the position of internal or of external rotation in which the leg as a whole lies. However, once a separation occurs, both the upper end of the neck and the lower end of the head cast shadows which are independent of each other and which are related to each other only by a formula expressing their angular relationship to the line of the bundle of rays. Once these facts were completely assimilated, it was realized that therein lay the explanation of the so called progressive "widening of the epiphyseal line", which has been described as pathognomonic of epiphysiolysis. It became obvious that this "widening" represented not a true, but an apparent increase in the width of the epiphyseal line. It was evident that the increase in the width of the epiphyseal line was caused by the gradual anteversion of the neck and that the roentgenographic visualization of this phenomenon was phaselike, similar to the waning and waxing of the moon. This was confirmed by the facts that anterior displacement of the femoral neck could be demonstrated only in those cases in which there was an increase in the width of the epiphyseal line and that the degree of the anterior displacement seemed to vary directly with the increasing width of the epiphysis. It further accounted for Pomeranz's observation that "the roentgenogram usually shows a widening of the epiphyseal line which is best demonstrated when the hip is examined with the leg in external rotation".

When the suggestion contained in this latter observation was carried into effect, an unexpected paradoxical situation developed. It was noted in Case 1 that, when the leg was externally rotated, as in Figure 2-B, the subcapital shadow disappeared, while on internal rotation it became very prominent. Because this was not observed characteristically in the acute cases, the paradoxical appearance was considered as typical of the late stage of the disease.* It was attributed partly to the condition produced by the superimposition of external rotation of the leg upon the anteversion of the neck, and partly to the fact that the epiphyseal surface of the neck lies not at a right angle, but oblique to the long axis of the neck. Both of these effects would be such as to modify materially the size and appearance of the subcapital shadow. However, since the detailed study of these effects is of interest only from a technical point of view and does not alter the primary argument, it is felt that the discussion may more properly be undertaken at some other time.

The matter of primary importance at this time is that both the clinical

* Figures 2-A, 2-B, and 2-C were taken rather late in the course of the disease after healing in malposition had occurred.

and the roentgenographic manifestations of the condition may be more adequately explained on the theory of anteversion of the neck of the femur than by any of the hypotheses previously advanced. Frangenheim and others have insisted that the characteristic microscopic appearance of epiphysiolysis is an actual physical widening of the epiphyseal plate, due to changes in its cartilage substance. By others, it has been contended that the epiphyseal plate is the seat of an "osteochondritis", which is the cause of the widening. Brailsford has called attention to the possibility that the condition is associated with renal rachitis, while the frequent association of that state of endocrine imbalance which is called Fröhlich's syndrome with epiphysiolysis is generally known. As concerns the latter two hypotheses, it may be stated that, while the association of these conditions is frequently noted, there is not the slightest assurance that either one is pathognomonic of the other. Epiphysiolysis may occur in the absence of renal rachitis or of Fröhlich's syndrome. On the other hand, either of these conditions may and does occur without the necessary development of epiphysiolysis. Even where both conditions are admittedly present, bilateral epiphysiolysis has been recorded in only about 15 per cent. of our series of over 100 cases. While the possibility exists that there is a definite relationship between these endocrinopathies and epiphyseal separations, it seems most likely that they act indirectly by predisposing the cervicocapital junction to the effects of trauma.

In regard to the former two hypotheses, it seems that they may be categorically denied. In this connection, it is interesting to note that a recent study by Sutro of three epiphyseal plates recovered at operation seems conclusively to dispose of the theories that the epiphyseal plate is the actual site of disease. Although the roentgenograms which he reproduced showed the characteristic widening of the epiphyseal line, his microscopic study exhibited no "definite evidence of primary degeneration of the epiphyseal plates". In his first case, he specifically stated that the capital epiphysis "had become flattened and as a result of the mushrooming had extended considerably over the neck, particularly toward the greater trochanter. On gross serial section the epiphysis was seen to bear evidence of being moderately sclerosed, especially beneath the covering cartilage of the portion which fitted into the acetabulum. Towards the greater trochanter the flattened epiphysis was somewhat atrophic." The second case showed "wavy, irregular, and reduplicated epiphyseal cartilage plates. . . . Very little endochondral ossification was present in the localized widened segments of the epiphyseal plate. Other portions of the plate, which were narrow, were undergoing closure." Case 3 similarly showed no evidence of cartilage proliferation in the epiphyseal region. His comment on these cases was as follows: "Histologic study of these specimens revealed no evidence of rickets, osteomalacia, or specific osteitis fibrosa. The pathologic condition may be interpreted as a fracture through the upper capital epiphyseal plate of the femur and through some of the contiguous osseous trabeculae."

Although Sutro's conclusion as to the nature of the condition is in all probability correct, considerable difficulty is experienced in following his explanation of the pathological principles underlying the condition. No attention is paid to the peculiar roentgenographic findings, and no mention whatsoever is made of the rotational element. The reader is left with the impression that the disease is characterized by a primary backward and downward slipping of the capital epiphysis. This, of course, is not the case. Although the factors to which Sutro calls attention undoubtedly play their part in the pathogenesis of the disease, the primary displacement is one of anteversion of the neck. The apparent slipping of the head downward, or of the shaft upward, is a secondary phenomenon. It occurs only after the anteversion has reached a maximum and the neck no longer supports the weight of the body transmitted through the head.

In this consideration, it appears that the attention of the physician should no longer be misdirected by stressing secondary effects in the denomination of the disease. Since the condition is in the nature of a fracture, it might be called a torsional or rotational fracture at the cervico-capital junction, or, better still, it might be renamed "epiphyseal coxa anteverta". While the term "epiphysiolysis" is not improper, in that it indicates a loosening of the epiphyseal plate, the terms "slipping of the capital femoral epiphysis" and "epiphyseal coxa vara" are distinctly bad because they are misleading. If the evidence here adduced is to be given credence, it must be considered as definitely established that primarily the capital epiphysis does not slip at all. During the whole process, as it was reproduced in the monkey hip, the head remained constantly in its normal relation to the acetabulum. In the acute stage, no matter whether the shaft was rotated inward or outward, or displaced upward or downward, the head remained in the acetabulum, held by the ligamentum teres and by the labrum glenoidale. At all times, it was the neck of the femur which slipped, not the head. It was only when the head became again fixed to the shaft, either by means of operative intervention or by means of healing in malposition, that the head followed the rotation of the femur. Furthermore, the primary and characteristic change in the position of the neck of the femur was not one of varus, but definitely and unequivocally one of anteversion. The varus position occurred only as a final stage in a process which had been developing and causing symptoms for weeks or months previously.

Even the term "coxa anteverta", which has been tentatively suggested, is not entirely accurate. On purely etymological grounds, the word "coxa" has no place in the description of the condition. In all propriety, the only correct term would be that which would describe an anteversion of the upper end of the femoral neck. However, since common practice has legitimatized the use of "coxa" in the sense of "neck", ample justification might be found for renaming the disease from its most characteristic finding. This term seems more capable of holding constantly before the surgeon a true picture of the pathogenesis of the condi-

tion and of its progress, and it gives a rational explanation of the clinical findings in the different stages of the disease.

In general, the progress of the condition may be divided into three main chronological stages, each of which has definite clinical and roentgenographic criteria. The first stage, called "the preslipped stage", is characterized by the onset of pain and limping, of varying intensity. Apart from a slight eversion of the foot, which is probably the earliest finding, there may be no objective signs. In this very early stage, the roentgenograms are usually reported as being negative. This, however, is the period during which the loosening or lysis at the epiphyseal plate is taking place. As the external rotation or eversion of the leg increases, the capital epiphysis follows until it reaches the limit of motion which the ligamentum teres permits. Up to this point, the head and neck are maintained in their comparatively normal relationships. Forward pointing of the foot, as in walking, permits an internal rotation of the head and neck. Beyond this point, continued eversion of the leg results in a change in the relationship between the head and the neck. Since the further rotation of the head is limited by the ligamentum teres, the continued eversion of the leg manifests itself as an anteversion of the neck of the femur at the epiphyseal line. Now, when the foot is pointed forward to permit normal progression, complete internal rotation is rendered impossible by the projection of the anteverted femoral neck. Flat or anteroposterior plates taken at this time will show the characteristic "widening of the epiphyseal line". If lateral plates are taken in addition to the simple anteroposterior views, it will be possible to demonstrate that the apparent widening of the epiphyseal line is occasioned by a gradual true anteversion of the upper or proximal end of the neck of the femur, and that the "preslipped" stage is characterized by a slipping which occurs only in an anteroposterior plane. As a consequence of the continued external rotation, a limit is reached beyond which the head finds no further support on the neck. At this extreme, a slight shortening of the leg length may be noticed. This point marks the end of the first period, which extends from the time of onset of symptoms to the time just preceding the actual upward displacement of the shaft of the femur.

The second stage is initiated by the abrupt onset of the symptoms of fracture of the neck. There is usually a history of trauma, in some cases of a specific trauma which causes an increased external rotation of the leg. In any case, there is immediate excruciating pain and inability to bear weight. The foot is usually everted, and there is shortening of the limb with elevation of the trochanter above Nelaton's line. Internal rotation, flexion, and abduction are limited. The anteroposterior roentgenogram shows characteristic upward displacement of the shaft of the femur. It will be especially noted, however, that in this phase of the affection the head is not rotated in any typical manner. It is retained in its normal position in the acetabulum and is usually of normal height. The shaft is seen to be surmounted by an elliptical shadow which varies in diameter

with the degree of external rotation of the extremity. The shaft may be rotated either internally or externally without materially or regularly affecting the position or appearance of the head in the acetabulum. This independence of the head is, of course, the consequence of the false point of motion, evidenced by the solution of continuity, the result of the fracture which occurred at the epiphyseal plate. It is the independent motion which is pathognomonic of the second phase of the disease. Its appearance marks the beginning of this phase; its disappearance marks the end of the second stage and the onset of the third or final period.

The third stage is that of fracture healed in malposition. Clinically, there are no symptoms of pain unless the condition is of long standing and is accompanied by secondary arthritic manifestations. There may be a limp, depending upon the degree of shortening, and there is definite limitation of internal rotation and abduction. The roentgenographic appearance may resemble that seen in Case 1. Stereoscopic roentgenograms and other views establish the fact that the neck is anteverted and that the head is situated upon the upper posterior edge of the neck. Roentgenograms showing internal and external rotation demonstrate that the motion of the shaft entails a corresponding motion of the head with variation in the apparent size of the capital epiphysis and of the subcapital elliptical shadow. This is the pathognomonic sign of the end stage of the affection. Thenceforth, the only changes to be noted are those consequent upon adaptations to the new set of stresses and strains which the new position of the head in its relation to the shaft of the femur determines.

From what has gone before, it appears that each phase of the disease is so essentially different that each requires a specific and different type of therapy. Treatment in the first stage (anteversion) should be dominated by preventive efforts; in the second stage (fracture), by restorative or reductive efforts; and in the third stage (malunion), by rehabilitative or reconstructive efforts. However, none of these technical attempts should be undertaken without consideration of the fact that "the more radical the surgical procedure, the worse the end results". The words are those of Pomeranz and Sloane but the opinion is, in effect, that of Key and others who have had extensive experience in the treatment of the condition.

This dictum applies with particular force to the treatment during the third stage,—the phase of malunion. When it is recalled that in this stage union has already occurred, the futility of manipulation, of drilling across the epiphyseal line, or of nailing the head to the neck will be realized. On the other hand, the justification for an extensive open operation to replace the head upon the neck, preliminary to nailing it in the new position, may well be questioned upon the basis of the end results. While it may be admitted that in some instances the results of extensive surgery, such as plastic reconstruction of the head of the femur or resection of the epiphyseal plate, have been satisfactory, it appears that as a general rule simpler measures give equally satisfactory results with far less risk. Osteotomy alone to correct alignment will do much to improve the functional outcome

and may do a great deal to prevent the late development of a secondary arthritis.

Treatment during the second stage of the disease consists essentially in the treatment of a fracture. As in dealing with other fractures, treatment must be divided into two steps: first, the reduction of the fracture and, second, the maintenance of the fragments until healing has taken place. By traction, the neck may be brought down to the level of the separated head and the shortening may be overcome. However, this alone is insufficient and the failure to correct completely the rotational deformity must be held responsible for the variable results which have been obtained. The procedure which has proved the most useful in the correction of bone deformities is the following: The patient is anaesthetized in the supine position. The operator takes a position between the legs, facing toward the patient's head. The affected limb is flexed and placed upon the operator's iliac crest. This supports the patient's limb and permits the surgeon the free use of both hands. Then, while the patient's pelvis is fixed, the surgeon grasps the limb, makes traction upon it, and at the same time forcibly rotates it internally. In the acute or even in the subacute cases, the reduction of the anteversion is manifested by a loud audible snap. The Leadbetter test usually indicates that reduction has been obtained, but neither this nor any other clinical test should be trusted as to the accuracy of the reduction. Roentgenographic examination, performed before the application of the plaster, in both the anteroposterior and the lateral positions, should be considered the only satisfactory evidence. However, since lateral views may be difficult to obtain, anteroposterior views may be used, provided that it be remembered that any roentgenogram, in which a wide epiphyseal line or an abnormal capital shadow is seen, presents positive proof of the inadequacy of the reduction.

This was shown very nicely in Case 1, in which, it will be recalled, an epiphysiolysis of the left hip developed while the patient was being treated for a similar condition in the right hip.

CASE 1. I. H. (*Continued*). In February 1936, the child began to complain of pain in the left knee. Clinical examination disclosed no evidence of any limitation of motion either in the knee or in the hip. A roentgenogram, taken on February 24, 1936, was reported as being "radiographically negative".

On April 13, 1936, the child was again brought for examination with the statement that the pain in the left hip was becoming more severe and that a slight limp was noticed. Examination revealed no limitation of motion, but the roentgenogram (Fig. 6-A), taken on April 15, 1936, was reported as showing "slight resorption of the neck of the femur adjacent to the epiphyseal line". The report further stated: "There is no slipping of the epiphysis at this time but the x-ray is suspicious of early slipping."

Five days later, the mother appeared in the Out-Patient Department and stated that the child was in severe pain and was unable to bear weight upon the left leg. An acute epiphysiolysis was diagnosed and the admission of the patient was forthwith directed. Both the clinical and the roentgenographic examinations confirmed the diagnosis. The roentgenogram (Fig. 6-B) showed a characteristic upward slipping of the shaft. The hip was exquisitely painful, and all motions were resisted. Under anaesthesia, the left leg lay in almost 90 degrees of external rotation. Flexion was possible only to 135

degrees, abduction to 45 degrees, and internal rotation to the neutral position. By means of the manoeuver previously described, reduction was effected with slight difficulty. Roentgenograms were taken in positions of internal rotation, in abduction without internal rotation, in flexion and internal rotation, and in abduction and internal rotation. The latter position seemed in this case, to give the best alignment of the head and neck. (See Figure 6-C.) The patient was consequently immobilized in a plaster-of-Paris bandage in the position of marked internal rotation (Fig. 6-D).

The excessive degree of internal rotation which was found necessary could be explained only on the following ground: As the leg was rotated internally, the posterior edge of the femoral neck impinged against the anterior rim of the head and passively rotated the head posteriorly, until its further motion was limited by tension on the ligamentum teres. It was only after this extreme of rotation had been obtained that rotation of the neck in relation to the head—that is, actual reduction of the fracture—occurred. Following reduction, the limb should be immobilized in that position which the roentgenogram shows to be optimum. In general, one may agree with Jahss that the position of flexion is better than that of extension. However, it seems that, of all the positions, it is most important to maintain the position of internal rotation. Experience shows that a combination of abduction and internal rotation with slight flexion is probably the best position for the greatest number of these cases. The following case was successfully treated in this manner as early as 1928.

CASE 3. J. H., a girl, was first seen privately in September 1928, at the age of eleven. The mother stated that the child had fallen about a year before, but there had been no

FIG. 6-A

Case 1. April 15, 1936. Note early widening of the epiphyseal line with what appears to be slight resorption of the neck adjacent to the epiphyseal line. This is the stage of anteversion.

FIG. 6-B

Case 1. April 20, 1936. Note the upward slipping of the shaft which is obviously externally rotated. This is the stage in which varus has been added to the anteversion.

symptoms until four months before examination, when a limp was discovered. This limp became more noticeable after exertion.

On clinical examination, both legs were of the same length. There was slight limitation of internal rotation. The roentgenogram showed a slight increase in the width of the epiphyseal line. The use of a hip brace was suggested to the mother, but this was refused, presumably because the author was not sufficiently stern in his insistence upon it. The patient was given general alpine exposure and cod-liver oil.

FIG. 6-C
Case 1. After reduction.

On October 20, 1928, the child was again examined, because of increasing pain. Clinically, there was increased limitation of internal rotation with limitation of abduction. No shortening could be determined. A roentgenogram was taken, which showed an increased "widening of the epiphyseal line". There seemed also to be a slight downward tilt of the head. Although at this time, the exact significance of these roentgenographic appearances was not realized, the development of what may be called a torsional fracture of the neck of the femur was taking place. However, the author again insisted upon the application of a brace, and the mother promised to give the matter consideration.

A few days later, while entering a restaurant, the patient inadvertently stubbed the inner side of her left toe against the lintel post of the door and thus sharply everted her foot and leg. She immediately fell to the floor, complaining of pain and inability to bear weight on the leg. She was taken directly to the Hospital, where a roentgenogram disclosed that the capital epiphysis had become dislocated. Under general anaesthesia, reduction was obtained with the leg in a position of wide abduction, marked internal rotation, and slight flexion. Roentgenographic examination showed satisfactory reduction, and a plaster-of-Paris spica bandage was applied and left on for a period of four months. At the end of this period, the patient wore a hip brace for ten months.

A follow-up roentgenogram, taken in October 1930, showed apparently solid union. Since that time, the patient has led a normal life, and, when examined in the latter part of 1935, showed no shortening or limitation of motion in any direction.

FIG. 6-D
Position of patient in the cast.

Treatment of the preslipped stage, or of what has been called here the stage of progressive anteversion, has been left for final consideration. The realization that treatment during this period

FIG. 7-A

Case 4. November 4, 1935. The "early preslipped" stage. There is only slight widening of the epiphyseal line. This is the earliest stage of anteversion.

FIG. 7-B

Case 4. March 2, 1936. Roentgenogram taken with the leg held in internal rotation by a brace. There has been a reduction in the apparent width of the epiphyseal line and a correction of the anteversion.

might spare both physician and patient the difficulties of treatment during the succeeding stage, has led to a variety of methods. With the object of preventing weight-bearing, the use of the Thomas walking caliper has been suggested. However, since the precipitating factor is, in all probability, a gradual or sudden external rotating force, it can be seen that without a device for insuring internal rotation the brace will be of no value, as many cases attest. With the purpose of obtaining premature ossification of the epiphyseal line, drilling across the epiphysis or impaction by means of the Cotton mallet has been recommended. The former method, a modification of a procedure which had been previously used in the treatment of non-united fractures and of other conditions, was employed, following a suggestion by Boszan for the treatment of Osgood-Schlatter disease. While the early results appear quite satisfactory, the method must not be considered entirely innocuous, since in one case calcification of the capsule with complete loss of all motion was the outcome of the operation. The second method, first suggested by Jahss, also appears to have given good early results. However, evidence is begin-

FIG. 7-C

Case 4. March 2, 1936. Lateral view, showing correction of the anteversion corresponding to the decrease in width of the epiphyseal line.

ning to accumulate that a mild form of arthritis may be one of the sequelae of this treatment. Thus, while each of these methods has its merits, it has also some drawbacks which justify the search for some still more harmless procedure.

Since the foregoing studies indicated that anteversion was of primary importance in the development of epiphysiolysis, it seemed natural to direct attention to that condition. It was suggested that, instead of watching with academic interest the gradual "widening of the epiphyseal line", efforts should be directed toward the cure or prevention of the disease before upward dislocation of the shaft occurred. Where the degree of anteversion was sufficient to warrant it, the patient should be anaesthetized; the anteversion should be corrected under roentgenographic control; and either a brace or a plaster-of-Paris bandage should be applied. Where the anteversion was slight, it was suggested that further progress of the condition be prevented by the application of a Thomas walking caliper, fitted to a pelvic girdle so as to maintain a marked degree of internal rotation, until closure of the epiphyseal line took place. Although the brace was intended merely to prevent the further progress of the anteversion, it succeeded beyond our best hopes, because it acted to correct the degree of anteversion which had existed prior to its application, as the following case demonstrates.

CASE 4. A. M., a boy, was first seen on November 4, 1935, some two months after he had fallen and injured his right hip. He had been examined at another orthopaedic hospital, and operation had been advised. Examination disclosed pain on all motions of the hip, with the characteristic limitation of flexion, abduction, and internal rotation. A roentgenogram (Fig. 7-A) was reported as showing "slight downward displacement of the right capital epiphysis". However, if the reproduction of this roentgenogram is carefully examined, it will be observed that, rather than a downward displacement, there is a disproportion between the long axes of the head and the neck of the femur, which gives the appearance of a downward displacement of the capital epiphysis.

When the patient was admitted to the Hospital, it was the author's intention to drill across the epiphyseal line. Because of the mildness of the condition, it was decided to observe the effect of purely conservative treatment. A walking caliper with a pelvic girdle was ordered, and, to prevent weight-bearing, a shoe with an elevated patten was prescribed for the opposite foot. (See Figure 8.) The affected foot was constantly kept in about 20 degrees of internal rotation by adjustment of the brace. Check-up roentgenograms (Figs. 7-B and 7-C), taken on March 2, 1936, showed, to the author's surprise, a decrease in the degree of anteversion. The patient did not complain of any pain or limitation of motion. When last seen, he was still free from symptoms.*

FIG. 8

The type of traction brace with pelvic girdle to insure internal rotation. Note elevated patten on opposite shoe.

* Because of the fact that closure of the epiphyseal line had not taken place, the result is herewith tendered as a preliminary note.

Since no case of epiphysiolysis can be considered as cured until the epiphyseal line has become permanently closed, it is obvious that early ossification of the epiphyseal line is urgently to be sought. In this respect, the method of drilling or of impaction has the advantage over treatment by the brace, or by the plaster-of-Paris bandage. On the other hand, attention must be called to the fact that x-ray exposure has been found to damage the epiphyseal plates. If it can be shown that such is the case and that, as a consequence, premature ossification of the epiphyseal line may be accomplished by x-ray therapy, a ready means will have been found whereby cure of the condition can be assured, once correction has been obtained. This can only be determined by further studies in this field.

SUMMARY

It is the author's opinion that so called epiphysiolysis is of the nature of a torsional fracture at the cervicocapital junction. The essential element in the production of the condition is the gradual and progressive anteversion of the neck of the femur. This is so characteristic that the disease should be renamed "coxa anteverta". The fundamental principle involved in the treatment of the disease lies in the prevention of the excess anteversion. This may be done by means of a brace with a pelvic-girdle attachment, in order to maintain internal rotation of the leg. In cases in which anteversion has proceeded to the point where the weight can no longer be supported and fracture with upward displacement of the shaft has occurred, reduction of the displacement under roentgenographic control and immobilization is recommended. The use of x-ray therapy for the purpose of premature ossification of the epiphyseal line is to be studied and reported upon at a later date.

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REFERENCES

Boszan, E. J., and O'Kane, T. J.: Treatment of Osgood-Schlatter Disease with Drill Channels. J. Bone and Joint Surg., XVI, 290, Apr. 1934.

Brailsford, J. F.: Slipping of the Epiphysis of the Head of the Femur. Its Relation to Renal Rickets. Lancet, I, 16, 1933.

Frangenheim, Paul: Weitere Untersuchungen über die Pathologie der Coxa vara adolescentium. Beitr. z. klin. Chir., LXXII, 239, 1911.

Jahss, S. A.: Slipping of the Upper Femoral Epiphysis. Treatment in the Pre-Slipping Stage. J. Bone and Joint Surg., XV, 477, Apr. 1933.

Displacement of the Upper Epiphysis of the Femur (Adolescent Coxa Vara) Treated by Closed Reduction. J. Bone and Joint Surg., XIII, 856, Oct. 1931.

Key, J. A.: Epiphyseal Coxa Vara or Displacement of the Capital Epiphysis of the Femur in Adolescence. J. Bone and Joint Surg., VIII, 53, Jan. 1926.

MacAusland, A. R.: Separation of the Capital Femoral Epiphysis. J. Bone and Joint Surg., XVII, 353, Apr. 1935.

Pomeranz, M. M., and Sloane, M. F.: Slipping of the Proximal Femoral Epiphysis. Therapeutic Results in One Hundred and One Cases. Arch. Surg., XXX, 607, 1935.

Sutro, C. J.: Slipping of the Capital Epiphysis of the Femur in Adolescence. Arch. Surg., XXXI, 345, 1935.

A STRAIGHT INCISION FOR ARTHRODESIS OR DRAINAGE OF THE SACRO-ILIAC JOINT

BY J. ALBERT KEY, M.D., ST. LOUIS, MISSOURI

From the Department of Surgery of the Washington University School of Medicine, St. Louis, Missouri

In the past the author has usually employed the Smith-Petersen operation for arthrodesis of the sacro-iliac joint. He has felt, however, that it was a rather formidable and difficult procedure and recently he has had two patients in whom separation of the subcutaneous tissues occurred, with the result that about two weeks after the operation the skin edges separated over a small area and a considerable amount of thin, yellowish fluid mixed with fat was evacuated. The wounds continued to drain over a period of three or four weeks and they healed slowly. This experience stimulated the writer to consider the possibility of exposing the desired area on the ilium through a straight-line incision and, consequently, the following operation was devised and has been used.

OPERATIVE TECHNIQUE

The patient is placed prone upon the table with the hips slightly flexed. The skin, having had a forty-eight-hour preoperative preparation, is painted with tincture of merthiolate and the patient is so draped that the left buttock, in the region of the posterior superior spine, and the posterior part of the sacrum are exposed. The incision through the skin begins close to the midline and passes outward and slightly downward about one-half an inch below the posterior superior spine of the ilium for a distance of about six inches toward a point about one-half an inch above the greater trochanter. (See Figure 1, *1*.) This incision is slightly more transverse than the fibers of the gluteus maximus muscle and is about one and one-half inches below the superior margin of the origin of this muscle from the ilium. The outer third of the incision lies above the upper margin of the gluteus maximus, and the superficial tissues are dissected from the thin fascia over the muscle and retracted (Fig. 1, *2*). The fascia and muscle origins on both sides of the posterior part of the crest of the ilium are cut. This incision runs around the posterior superior spine, as shown by the dotted line in Figure 1, *2*, and, on the lateral aspect, part of the origin of the gluteus medius is cut. The gluteus maximus and the gluteus medius are fused near their origin, but can be separated in the lateral part of the wound. Then, by blunt dissection, the superior border of the gluteus maximus is freed up to its origin and the muscle is retracted downward. Next, the inferior margin of the gluteus medius is stripped up from the ilium and retracted upward, thus exposing the portion of the bone between the posterior part of the crest and the greater sacrosciatic notch.

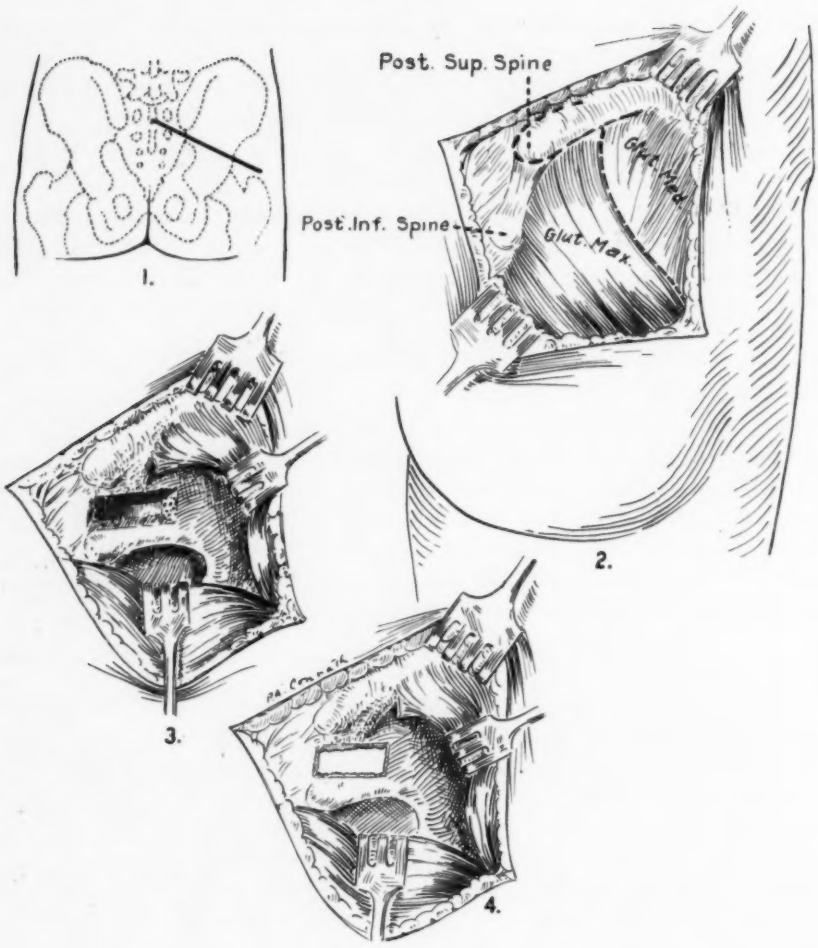

FIG. 1

Showing the steps in the operation:

1: Projection of skin incision on pelvis for arthrodesis of the right sacro-iliac joint.

2: Superficial tissues retracted to show the muscles and posterior part of the iliac crest. The fascia and muscle origins are cut from the crest, as shown by the dotted line, and the muscles are either separated or cut along the superior margin of the gluteus maximus, which is indicated by a dotted line.

3: The muscles have been separated from the ilium and retracted, and the window has been made in the ilium.

4: After the window has been extended into the sacrum, the plug is driven in and countersunk to effect an arthrodesis.

(In the illustrations, the retraction is slightly more marked than is actually obtained at the operation.)

The superior margin of this notch lies just below and parallel to the skin incision.

An alternative method is to carry the incision directly downward through the muscle to the bone just above the margin of the greater sacro-sciatic notch, thus sacrificing a small part of the gluteus medius. The

periosteum and muscle origin of the posterior portion of the gluteus medius are separated from the bone and stripped upward to expose the part of the ilium above the greater sacrosciatic notch, and the periosteum along the border of the notch is stripped downward to expose this border. The tissue over the greater sacrosciatic ligament is stripped downward and that part of this ligament over the posterior margin of the sacro-iliac joint, including the posterior sacro-iliac ligaments, is removed to expose the margin of this joint.

We thus have a straight incision with the gluteus maximus below and the gluteus medius above, the incision being roughly parallel to the superior border of the greater sacrosciatic notch. By retracting the margins of the wound, exposure of the posterior portion of the ilium over the posterior part of the sacro-iliac joint is obtained. The superior gluteal vessels may or may not be seen, although they lie in the tissues deep in the lateral portion of the wound. They are not cut unless they are injured. The periosteum is stripped back around the posterior superior region of the greater sacrosciatic notch, and a window is cut from the ilium with osteotomes. It extends from the posterior border of the ilium, between the posterior superior and posterior inferior spines, directly forward and parallel to the margin of the sacrosciatic notch (Fig. 1, *3*). This window includes the full thickness of the ilium in this area and is about one-half an inch wide and an inch and a half long at the posterior part and about three-fourths of an inch wide in its anterior portion. This dowel of bone is then removed and usually contains part of the surface of the sacro-iliac joint and some tissues just posterior to this joint. In other words, the window is slightly wider than the joint at this point and is cut at a sufficient distance from the margin of the sacrosciatic notch to leave an adequate bridge of bone in that area (Fig. 1, *4*). It is approximately the window which Smith-Petersen described in his second procedure, published in 1926.

After the window has been made, the opening through the ilium is deepened into the sacrum. The exposed margin of the joint is curetted or removed with an osteotome, and small bits of cancellous bone are packed into the joint between the ilium and the sacrum. Then the deep surface of the plug is excised or roughened (the author usually cuts a number of parallel depressions across it with small, sharp rongeur forceps), and the plug is driven back into its original hole and countersunk until it extends into the sacrum about one-third of an inch. The margins of the hole in the ilium are cut off obliquely with an osteotome and the bone chips are placed over the posterior part of the sacro-iliac joint, after a small bit of the cortex of the sacrum has been lifted with an osteotome to admit the grafts. The wound is closed by a few sutures of No. 1 chromic catgut; these sutures pull up the lower margin of the gluteus medius to the region near the posterior superior spine, and the superior part of the origin of the gluteus maximus to the crest of the ilium and posterior superior spine. Next, about three chromic sutures are put in the deep subcutaneous tissue

to relieve tension from the skin edges. The subcutaneous fat is closed with No. 000 plain catgut and the skin is closed with silk. The small vessels which are encountered during the operation are usually tied after the skin towels have been placed.

The cutting of the fascia and origin of the muscles from the posterior part of the crest of the ilium is not a part of the arthrodesis, but is done on the basis that this fascia may be a factor in causing the pain.[1]

The author has used this incision seven times in performing an arthrodesis of the sacro-iliac joint and once for drainage of this joint; in each instance the exposure has been satisfactory and the wound has healed without complications. It has also been the writer's impression that these patients have had less postoperative shock than have those on whom he has performed sacro-iliac arthrodeses by other methods.

REFERENCES

1. Ober, F. R.: The Rôle of the Iliotibial Band and Fascia Lata as a Factor in the Causation of Low-Back Disabilities and Sciatica. J. Bone and Joint Surg., XVIII, 105, Jan. 1936.
2. Smith-Petersen, M. N., and Rogers, W. A.: End-Result Study of Arthrodesis of the Sacro-Iliac Joint for Arthritis—Traumatic and Non-Traumatic. J. Bone and Joint Surg., VIII, 118, Jan. 1926.

AUSCULTATION OF JOINTS*

BY A. STEINDLER, M.D., F.A.C.S., IOWA CITY, IOWA

Professor of Orthopaedic Surgery, The State University of Iowa

HISTORICAL SURVEY

The idea of applying auscultatory findings to the diagnosis of pathological changes in the locomotor system is not new. Hueter, in 1885, tried to localize joint bodies by means of his myo-dermato-osteophone, and Blodgett, in the United States, in 1902, reported stethoscopic findings of creaking, grating, and cracking joint sounds, most marked in chronic arthritis.

In 1906, Ludloff, who, on auscultation of spine, sacrum, and pelvis, had observed creaking and cracking sounds similar to those found in arthritis of the knee, went so far as to locate arthritis deformans of the cervical spine by circumscribed friction noises at the atlanto-occipital region, and sacro-iliac arthritis by crepitation at the posterior iliac spines. In the knee, the first meniscus investigations by auscultation were reported by Bircher in 1913. A large number of observations were recorded by C. F. Walters in 1929. In his examination of 1600 joints, he noted the gradual increase with the years in the grating intensity. In a series of unselected cases the auscultatory findings showed an increase in intensity from 1.5 per cent. in the first decade to 81.5 per cent. in the eighth. He also emphasized the fact that the finest grating is a sign of early arthritis, when no other clinical symptoms are present.

As far as the author has been able to determine, the first graphic presentation of joint noises was made by Erb in 1933. By using a contact microphone instead of air transmission, he believed that it was possible to exclude extraneous noises. Erb recorded the results of investigation of a number of sound knees, as well as of cases of chondromalacia of the patella, of arthritis deformans, and of meniscus lesions, and he pointed out the rather low frequency of meniscus sounds.

TECHNIQUE

For a number of years the writer systematically practised auscultation of joints, especially of knees, with the ordinary clinical stethoscope. Lately, he has supplemented this procedure by examination with the so called cardiophone (Fig. 1). This is an instrument consisting of a diaphragm which is connected with a crystal; the whole is enclosed in a polished metal case with a short bell piece attached to it. A soft-rubber attachment eliminates the friction noises of the skin. This microphone is peculiarly free from microphonics (*i.e.*, handling noises), while the contact

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FIG. 1

The cardiophone: diaphragm with crystal in metal case, bell piece, and rubber attachment.

microphone in the writer's experience is much more sensitive to handling and friction noises. By passing the sound from the cardiophone through an amplifier to an oscillograph, oscillographic records of the sound waves are made. (See Figure 2.)

There are two great problems in the interpretation of sound phenomena: First, it is difficult to eliminate extraneous and extra-articular noises; and, second, it is not easy to locate the sound center,—that is, the exact spot from which the sound originates.

In order to exclude extraneous noises, such as friction, rubbing, and gliding of the instrument, great care is taken to apply the stethoscope or cardiophone firmly, but not too tightly, so that it will not shift during the examination.

A so called high-pass filter is used in connection with the amplifier, which cuts out all noises under 130 oscillation frequency. This disposes of the tremor noises which arise from the tremor of the hand holding the

FIG. 2

Arrangement for making an oscillographic record. Oscillograph and camera (left). Amplifier (background).

microphone. The sounds recorded in the oscillogram were in the range from 130 to 1100 oscillations, embracing about three octaves.

So far, it has not been possible to differentiate between extra-articular and intra-articular noises on the basis of the sound picture, since both occur in the same frequency limits and, especially, since they are all discontinuous in the stricter sense, even the sustained crunching and grating sounds heard in the arthritic knee. (See Figure 3.) However, with some practice, extra-articular snaps and pops, usually from jumping tendons, can be recognized by their character and location as originating outside the joint cavity.

As an aid in locating sounds, the knee is divided into four quadrants: a lower inner, medial to the patellar tendon; a lower outer, lateral to this tendon; an upper inner, medial to the quadriceps tendon; and an upper outer, lateral to the quadriceps tendon. Sometimes the auscultations are taken over the patella. In the upper outer quadrant the snapping ilio-tibial band must be avoided.

In order to distinguish between sound intensity in the different quadrants, a binaural stethoscope was devised by Mr. E. L. White, physical assistant in the Department. This instrument may be used and developed so as to be of great help in locating sounds.

In order to determine the position of the joint at which a sound is recorded, we used a goniometer, graded in intervals of 30 degrees and electrically connected with the oscillograph. Thus, by the opening and closing of contacts, the joint position is marked on a special line on the photographic paper. So far, this arrangement has served well, but better methods, which are more time-saving and less noisy, can be developed.

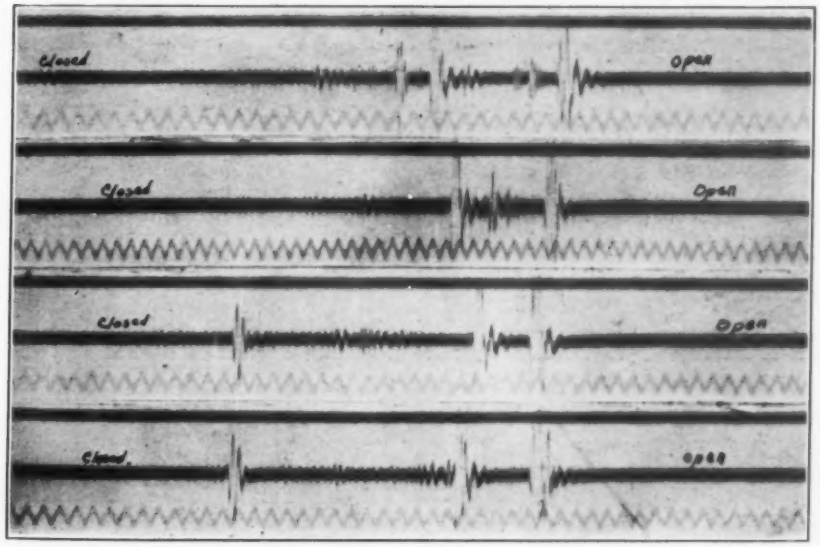


FIG. 3

Case 21. Extra-articular noise. Snapping of extensor tendon in hand.

Time is also recorded on a special line on the tape in one-hundredths of a second.

The photographic record thus shows three lines: the uppermost or position line, which gives the position of the joint in relation to the occurrence of the sound; the middle line, which records the sound itself, the height of the curve designating the intensity of the sound; and, finally, the time line at the bottom, which indicates the frequency of the sound.

CLASSIFICATION

Joint sounds were classified according to:

1. Pitch (frequency)—high or low.
2. Amplitudes of waves—loud or weak.
3. Sequence—sustained or isolated.
4. Quality (overtones, complexity of sound curve).

We used the following nomenclature:

1. Crunching (very fine, low, weak, a sustained sound).
2. Grating (coarser, higher, louder, also sustained)
    a. fine
    b. medium
    c. coarse.
3. Cracking (a harsh, sustained, high-pitched sound)
    a. fine
    b. medium
    c. coarse.
4. Isolated sounds
    a. isolated single cracks
    b. sharp pops or snaps
    c. low thuds.

Both grating and cracking are really discontinuous, although they

TABLE I

AUSCULTATION OF NORMAL KNEES (62 KNEES, OR 15.61 PER CENT.)

Quadrants	Silent	Crunching	Grating and Crunching	Grating			Grating and Cracking			Isolated Sounds		Total
				Fine	Medium	Coarse	Fine	Medium	Coarse	Crack	Snap	
Lower Inner	0	1	1	7	2	0	2	0	0	0	1	14
Lower Outer	0	1	0	2	0	0	0	0	0	0	0	3
Upper Inner	0	0	0	0	0	0	0	0	0	0	0	0
Upper Outer	0	0	0	3	1	0	0	0	0	0	2	6
All	22	0	0	9	5	1	0	1	0	1	0	39
Total	22	2	1	21	8	1	2	1	0	1	3	62

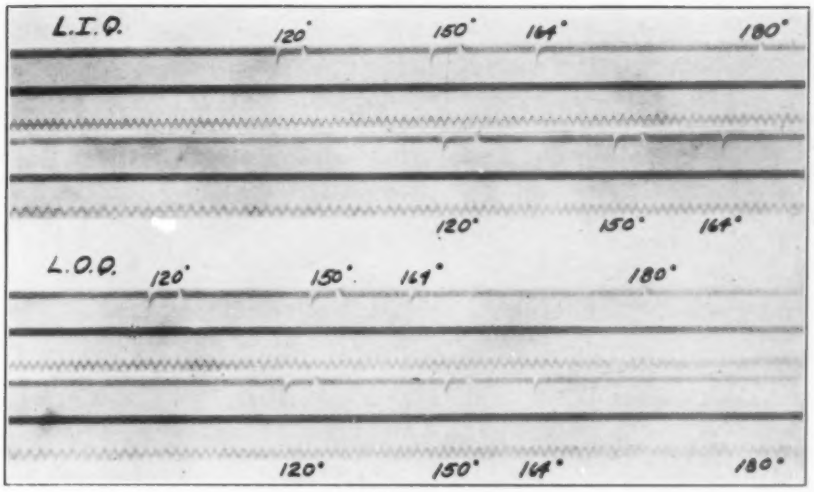


FIG. 4

Case 64. E. J. Oscillogram of the normal knee of a child, showing the lower quadrants which are silent. *L.I.Q.* = lower inner quadrant; *L.O.Q.* = lower outer quadrant.

may sound sustained. They often break up in the oscillogram into a sequence of isolated cracks.

NORMAL KNEE-JOINT SOUNDS—62 CASES

Of the 397 knees examined, sixty-two were normal. The physiological normal intrinsic sounds found in these normal knee joints were classified according to the ages of the patients.

In children under ten, the joint was almost uniformly silent in all cases. (See Figure 4.)

In adolescents and in young adults, the knee was also silent in all quadrants with the exception of very fine grating which occurred usually at the terminal positions.

In the adult past middle age, more or less continuous soft grating,

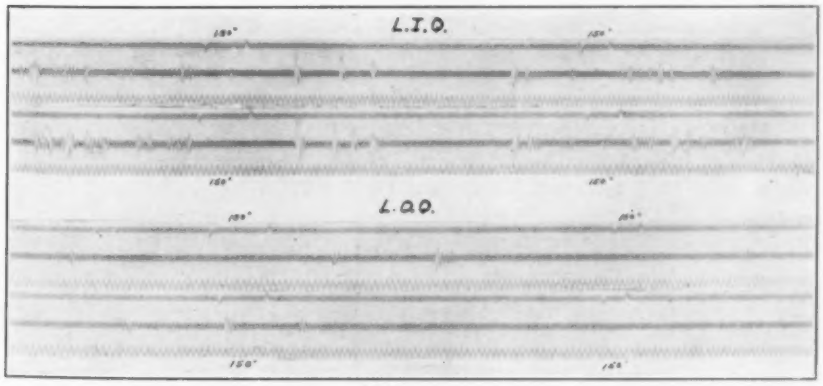


FIG. 5

Case 54. M. R. Arthritic knee. Harsh cracks in lower inner quadrant.

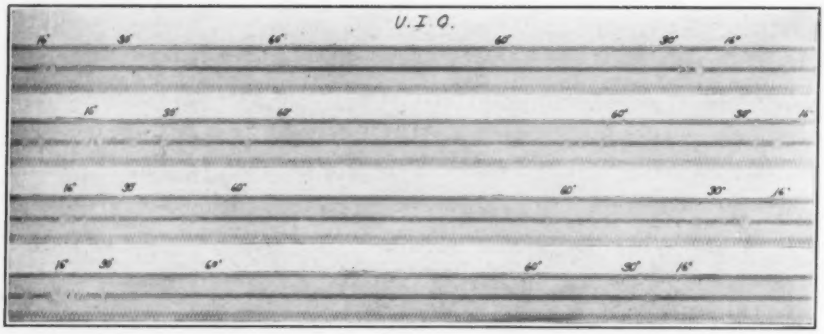


FIG. 6

Case 16. J. C. Arthritis sicca. Harsh grating in all quadrants with the knee in flexion and in extension. *U.I.Q.* = upper inner quadrant.

accentuated at the terminal positions, was common, especially in women near the menopause.

Table I shows a predominance of silent knees. In approximately one-half of the knees which were not silent, grating was present in all quadrants. Most of this grating, even in isolated cases, was of a fine nature.

The soft grating noise is occasioned principally by the intrusion of the ligamentum mucosum and the fat pads between the femoral and tibial condyles as the knee goes into full extension, and, also, by the crowding of the posterior portion of the cartilages between the joint bodies in full flexion.

PATHOLOGICAL KNEE-JOINT SOUNDS

General Joint Lesions

Arthritis—216 Cases

The sound consists of grating and cracking over full range, accentuated at the terminal positions by isolated clicks or cracks, but without very definite localization. (See Figure 5.)

TABLE II

STETHOSCOPIC FINDINGS IN ALL TYPES OF ARTHRITIS OF THE KNEE
(216 KNEES, OR 54.41 PER CENT.)

Quadrants	Silent	Crunching	Grating			Grating and Cracking			Isolated Noises			Isolated Cracks and Grating	Total
			Fine	Medium	Coarse	Fine	Medium	Coarse	Pop	Thud	Snap		
Lower Inner..	0	0	7	4	1	0	1	2	0	0	0	0	15
Lower Outer..	0	0	3	1	0	1	0	3	1	1	0	0	10
Upper Inner..	0	0	2	0	0	0	0	0	0	0	1	0	3
Upper Outer..	0	0	1	0	0	0	0	0	0	0	0	0	1
All.....	19	3	71	34	22	5	6	16	3	0	4	4	187
Total.....	19	3	84	39	23	6	7	21	4	1	5	4	216

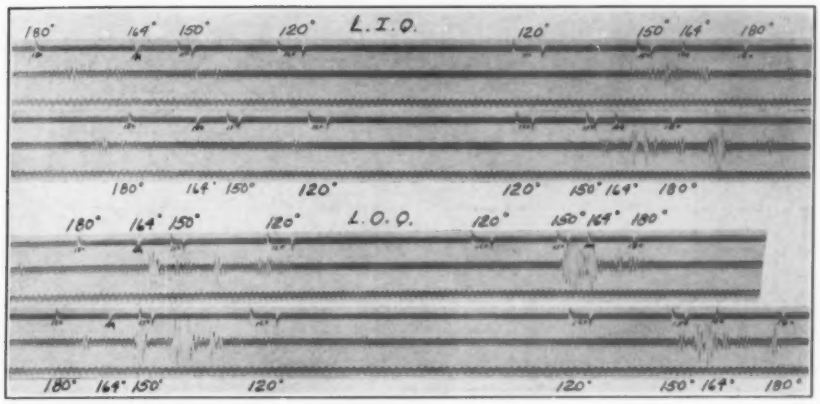


FIG. 7

Case 30. E. R. Post-traumatic arthritis. The semilunar cartilage has been removed. Lockage and swelling are still present. The harsh grating and isolated clicks indicate arthritic changes plus definite mechanical impediment. Good correlation.

Table II shows a predominance of knees in which fine and medium grating sounds were present in all quadrants. There was a definite absence of isolated sounds in the separate quadrants.

Sharp grating in all quadrants in most of the ranges was particularly noted in a case of degenerative atrophic arthritis (Fig. 6).

CASE 16. J. C. Operation revealed hypertrophied villi, pannus formation, thickened synovia, fibrous adhesions in the suprapatellar pouch, and chondromalacia of the patella. The distribution of grating denoted a general involvement of the joint; there was no localization. There was good correlation between the stethoscopic, cardiophonic, and oscillographic records.

CASE 30. E. R. This patient had post-traumatic arthritis. Although the left semilunar cartilage had been removed, relocking and swelling were still present. The auditory findings were harsh grating in all quadrants, indicating the generalized arthritic changes, and a definite click in the lower outer quadrant, indicating some mechanical impediment. (See Figure 7.) There was good correlation between the stethoscopic, cardiophonic, and oscillographic findings.

Villous arthritis was present in twelve cases. In this type there is continuous soft grating in all quadrants. The grating becomes harsher with increasing induration of the villi. The history of repeated traumatic locking indicates more severe traumatization of the villi.

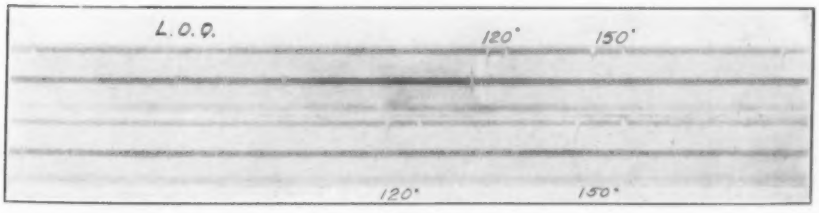


FIG. 8

Case 69. J. F. Villous arthritis. Soft grating. Good correlation. Operation showed hypertrophied fat pads.

TABLE III

CASES OF OSTEOCHONDRITIS DISSECANS (23 KNEES, OR 5.79 PER CENT.)

Quadrants	Silent	Crunching	Grating			Grating and Popping			Isolated Sounds			Isolated Thud and Grating	Isolated Crack and Grating	Total
			Fine	Medium	Coarse	Fine	Medium	Coarse	Pop	Thud	Snap			
Lower Inner	0	0	1	0	0	1	0	0	0	0	0	0	1	3
Lower Outer	0	0	0	0	0	0	0	1	0	1	0	1	0	3
Upper Inner	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Outer	0	0	0	0	0	0	0	0	1	0	0	0	0	1
All	2	1	5	1	0	1	0	0	0	0	3	0	3	16
Total	2	1	6	1	0	2	0	1	1	1	3	1	4	23

CASE 69. J. F. This patient was fifty-five years old and had villous arthritis. Preoperative auditory findings revealed continuous soft grating in full range in all quadrants. (See Figure 8.) There was good correlation between the stethoscopic, cardiophonic, and oscillographic findings. The operation showed hypertrophic arthritis with large hypertrophied fat pads.

Osteochondromatosis—3 Cases

Of the three cases of osteochondromatosis, one displayed fine grating in all quadrants, while the other two gave evidence of coarse grating and cracking.

As one would expect, the auditory signs are marked by multiple,

TABLE IV

DERANGEMENT OF THE INTERNAL SEMILUNAR CARTILAGES
(57 KNEES, OR 14.36 PER CENT.)

Quadrants	Silent	Crunching	Grating and Crunching	Grating			Grating and Cracking			Isolated Sounds			Thud and Cracking or Grating	Total
				Fine	Medium	Coarse	Fine	Medium	Coarse	Thud	Crack	Snap		
Lower Inner	0	2	0	7	0	1	1	0	1	2	0	2	0	16
Lower Outer	0	0	0	1	0	0	0	1	1	1	1	2	0	7
Upper Inner	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Upper Outer	0	0	0	1	0	0	0	0	0	0	0	1	0	2
All	4	0	0	8	3	2	0	1	2	0	1	9	1	31
Total	4	2	0	17	3	3	1	2	4	3	2	14	2	57

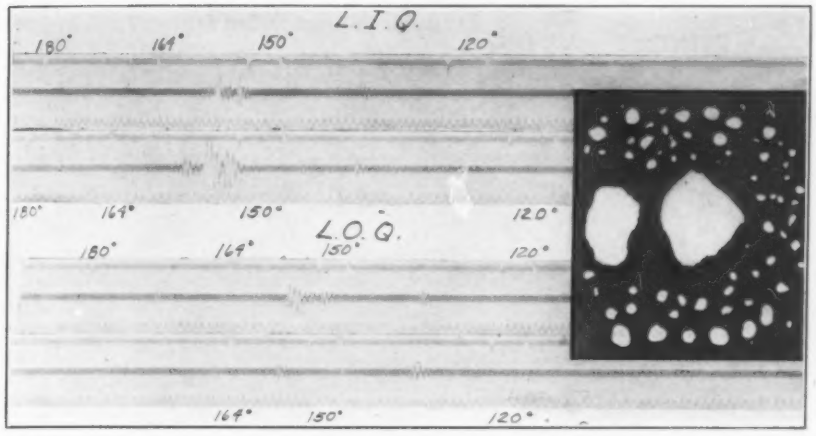


FIG. 9

Case 58. A. G. Osteochondromatosis of the left knee. Isolated sharp cracks in the lower quadrants. Good correlation.

sharp, isolated cracks in one or more quadrants, very inconstant as to location, upon a background of general more or less sharp, high-pitched grating. The intensity of the sounds, as well as the pitch, is greatly influenced by the degree of effusion.

CASE 58. A. G. In this case examination revealed osteochondromatosis of the left knee. Isolated sharp cracks were audible in the lower quadrants, as well as in the upper inner quadrant, with continuous sharp grating. (See Figure 9.) There was good correlation between the stethoscopic, cardiophonic, and oscillographic findings. The operation showed scarred fat pads, degenerative changes at the medial femoral condyle, and numerous small bodies.

The diagnosis, of course, was made on the usual physical and roentgenographic examinations, but the auditory findings indicated the general arthritic reaction of the joint.

Localized Joint Lesions

Osteochondritis Dissecans—23 Cases

If there is an arthritic background, the general joint sounds which have been described are heard without particular localization. The auscultatory findings of the free body or bodies depend on the location. If the free body is situated in the anterior compartment, a loud click is heard near full extension.

Table III shows the absence of isolated sounds. In this group there were six knees in which isolated sounds were heard in all quadrants. The fine grating was associated with the knees which showed the most arthritic changes.

CASE 23. G. R., fifty-nine years of age. The stethoscope and cardiophone revealed medium sharp grating in all quadrants, with the knee near full extension. The grating was at its maximum in the lower outer quadrant. In addition, there was a loud click in the lower inner quadrant, with the knee near full extension.

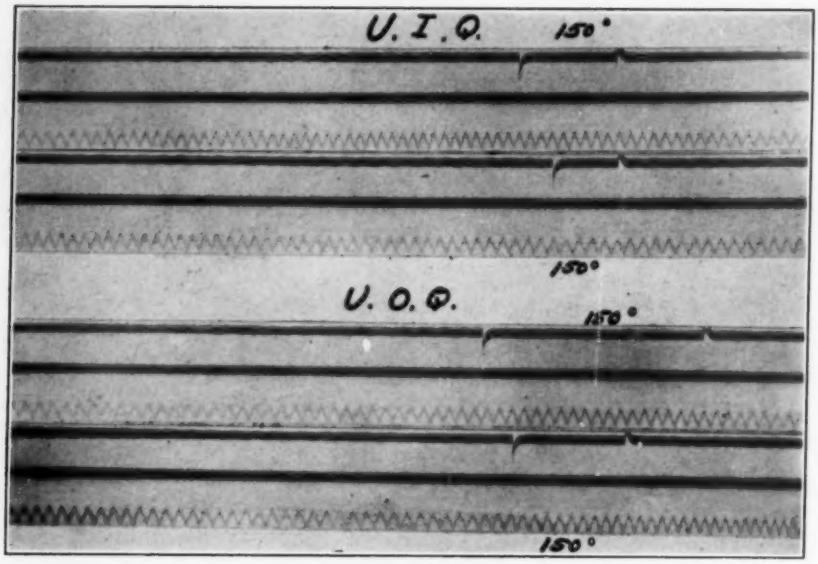


FIG. 10

Case 23. G. R. Osteochondritis dissecans. Postoperative oscillogram, showing some slight universal grating. The sharp grating and isolated clicks have disappeared.

A parapatellar incision was made, and the joint showed hypertrophied fat pads and a free body in the lower inner quadrant. Following the operation, the universal grating remained, but the click had disappeared. (See Figure 10.)

In another case of osteochondritis dissecans (G. K.), the stethoscope revealed in the upper outer quadrant a sharp, loud, cutting sound at the outer margin of the patella. When the knee was opened by a median parapatellar incision, a free body was found in the lateral compartment. The defect in the median femoral condyle was scarred over. There was also a chondromalacia of the patella, but this condition produced no sound.

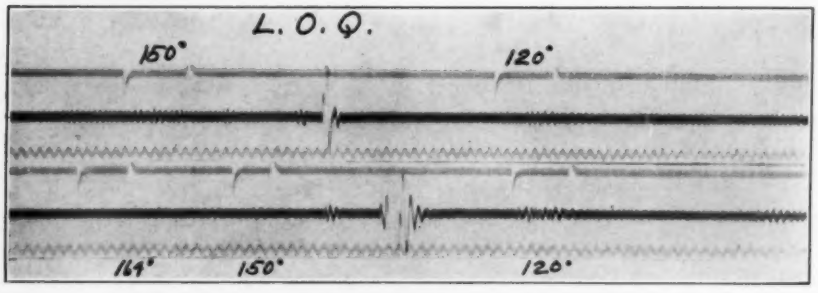


FIG. 11

Case 71. J. V. Injury to the internal semilunar cartilage of the left knee. No operation was performed. The stethoscope and cardiophone revealed a dull thud in the lower inner quadrant and a click in the lower outer quadrant. The oscillogram carries the click only.

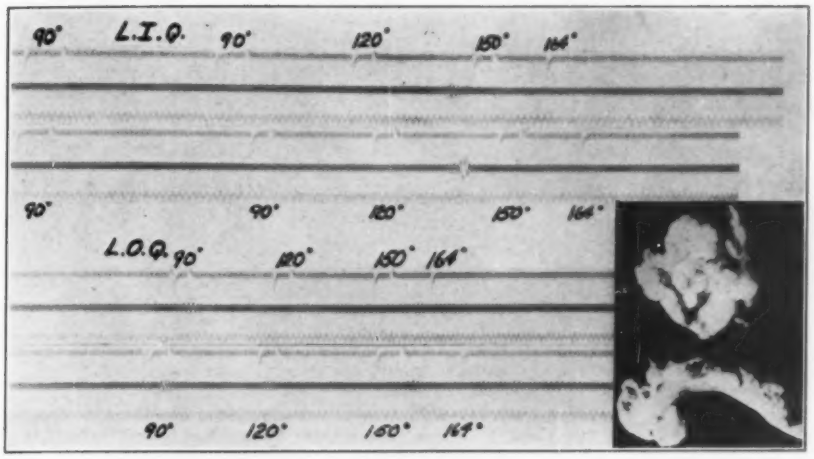


FIG. 12

Case 67. M. M. Injury to the internal semilunar cartilage of the right knee. In this case an operation was performed. The lateral meniscus of the other knee had been removed previously. The stethoscope and cardiophone recorded a dull thud at 140 degrees. The oscillogram shows a distinct thud at the same point. At operation a fracture of the internal semilunar cartilage was revealed.

Injuries to the Semilunar Cartilages—57 Cases

These cases were especially interesting, as auditory findings gave information in regard to locking, which was not obtained from the history or from the clinical examination. Both character and location of sound were of importance. On quite a number of occasions a dull thud was heard in the lower inner quadrant, either on completion of extension or on completion of flexion, and we believe that this is suggestive of cartilage injury. When the internal meniscus was involved, the location of sound origin was regularly the lower inner quadrant, and in a number of doubtful cases the approach to the joint was thereby indicated and corroborated by operative findings.

FIG. 13

G. C. Injury to the internal semilunar cartilage of the left knee. The stethoscope revealed a sharp click with the knee in complete extension, with the feeling of replacement in the lower quadrants. The click was not constant. At operation, through a parapatellar incision, a fracture of the internal semilunar cartilage with inside displacement of the flap (floating) was found.

Table IV shows that there was a tendency for the isolation of sounds in definite quadrants. In sixteen knees the sounds were localized in the lower inner quadrant and in seven knees in the lower outer quadrant. Those knees in which there was grating in all quadrants probably had associated arthritic changes.

The following case is illustrative of the findings in non-operated cases.

CASE 71. J. V. In this case of injury to the internal semilunar cartilage, the pressure point was the lower inner quadrant. The stethoscope and cardiophone revealed a dull

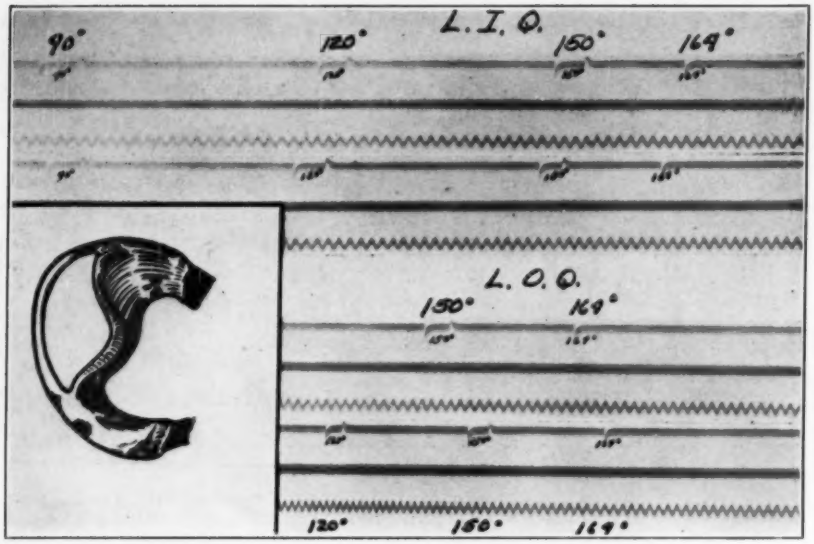


FIG. 14

Case 18. R. G. Postoperative. Injury to the external semilunar cartilage of the right knee. The stethoscope disclosed a sharp click in the lower outer quadrant with the knee in extension; the cardiophone gave the same result. At operation, through the Jones incision, a bucket-handle fracture of the external semilunar cartilage was revealed. Postoperative stethoscopic, cardiophonic, and oscillographic examinations showed that the click had disappeared. Good correlation.

thud at the lower inner quadrant upon completion of extension and a sharp click at the lower outer quadrant. Ths oscillogram carried the click, but not the thud, possibly because the knee was not fully extended. (See Figure 11.) These findings indicated some lesion of the anterior portion of the internal semilunar cartilage.

The same dull thud was heard in other cases in the lower inner quadrant, with the knee in extension, correlating the stethoscopic and the oscillographic findings, and was also interpreted as due to internal semilunar injury. Clinical findings were locking and pain.

After these experiences it was of particular interest to check up the auditory findings in operated cases.

CASE 67. M. M., seventeen years of age, sustained an internal derangement of the right knee. Sudden locking occurred, and there was pain on the medial side. This patient had been operated upon before for a bucket-handle fracture of the lateral meniscus of the opposite knee. Both stethoscope and cardiophone recorded a dull thud at the lower inner quadrant between 80 and 180 degrees, indicating that the sound was more probably localized in the posterior compartments. Operation on the right knee showed a longitudinal fracture of the internal cartilage. (See Figure 12.)

CASE 3. P. D., thirty-six years of age, experienced frequent locking and pain on the lateral aspect of the left knee. The stethoscope recorded a dull thud in the lower inner and outer quadrants between 60 and 90 degrees. The cardiophonic findings tallied with the stethoscopic. The diagnosis was tear, probably of the internal cartilage, but, because of the ambiguity of the localization, a parapatellar incision was made. This showed a transverse tear of the internal semilunar cartilage, with the fragment curled up, which probably accounted for the thud. A pop, heard once at earlier examination, probably meant temporary engagement of the lateral free end. The preoperative diagnosis,

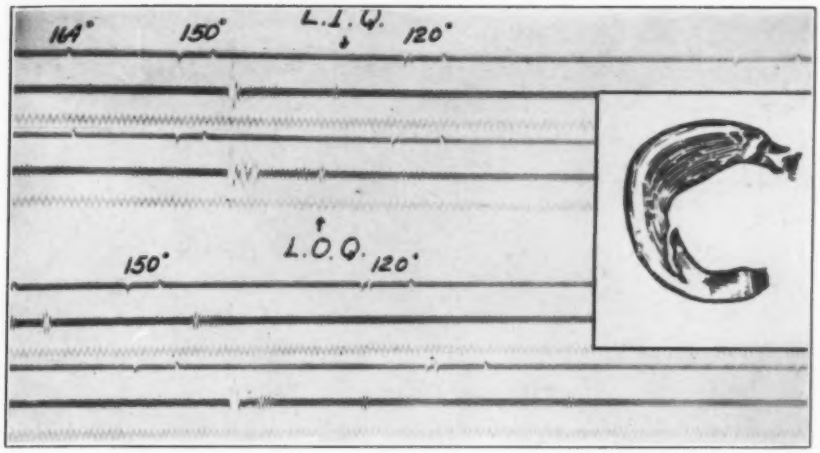


FIG. 15

Case 41. O. K. Preoperative. Injury to the internal semilunar cartilage of the left knee. Stethoscopic and cardiophonic examinations revealed a dull thud in the lower inner quadrant, with the knee near complete extension; in the lower outer quadrant, the thud was less audible. Oscillographic examination gave the same result. At operation, through the Jones incision, a double fracture of the semilunar cartilage was found. Absolute correlation.

made on the history, clinical examination, and auditory findings, was confirmed by operation.

Sharp clicks seem to denote injury to the semilunar cartilage, if they occur at terminal points, and they are often associated with a feeling of displacement.

CASE G. C., thirty-two years of age. This patient sustained an internal derangement of the left knee. There was a history of catching, lockage, and inability to extend the knee. These attacks had been numerous. Tenderness was present over the internal semilunar cartilage. The stethoscope revealed in the lower inner and the lower outer quadrants a sharp click with the knee in complete extension, associated with a feeling of replacement. (See Figure 13.) A parapatellar incision was made, but we believe that the internal Jones incision would have been justified on the basis of the physical and auditory findings. Operation revealed rupture of the internal semilunar cartilage near the anterior end with inside displacement of the flap. The click heard before operation was not constant, which indicated a detachable body,—a free body or a ruptured semilunar cartilage with a movable fragment. Operation confirmed the diagnosis.

CASE 18. R. G. In this case there was a fracture of the external semilunar cartilage of the right knee. The stethoscope revealed a sharp click in the lower outer quadrant, with the knee in complete extension. The cardiophone recorded the same click in the same location. Therefore, a Jones incision was made over the external cartilage, and a bucket-handle fracture was found.

After operation, both stethoscopic and cardiophonic examinations revealed that the click had disappeared from the lower outer quadrant, and the oscillogram showed only moderate roughness. (See Figure 14.) This is a case in which the diagnosis absolutely confirmed the auditory findings.

CASE 41. O. K. This patient sustained anterior and posterior longitudinal fractures of the internal semilunar cartilage of the left knee. The stethoscope and the

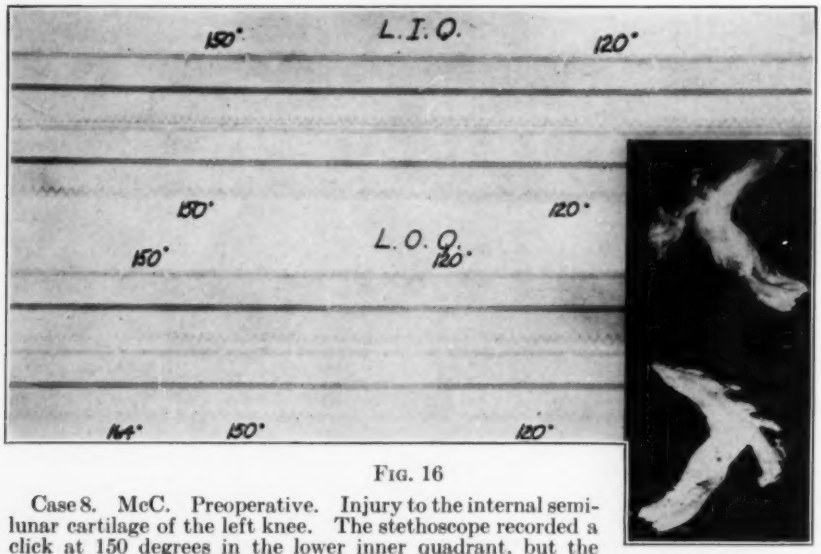


FIG. 16

Case 8. McC. Preoperative. Injury to the internal semilunar cartilage of the left knee. The stethoscope recorded a click at 150 degrees in the lower inner quadrant, but the cardiophone and oscillograph were silent. Operation revealed detachment of the anterior half of the internal semilunar cartilage, which slipped without an audible click. Good correlation. The stethoscopic findings were the most reliable.

cardiophone revealed a dull thud with the knee in or near complete extension. (See Figure 15.) This coincided with the clinical findings and, accordingly, a Jones incision was made over the lower inner quadrant of the left knee. A double fracture of the internal semilunar cartilage was found,—the first extending along the medial border and the second being a fish-tail fracture of the anterolateral attachment. There was also an erosion of the anterior portion of the femoral cartilage, which was trimmed off. This case absolutely coincided with the diagnosis made, both clinically and by auditory findings.

In the following cases, no thuds or clicks were present.

CASE 8. McC., thirty-five years of age, was found to have suffered an internal derangement of the left knee, with repeated lockage and catching. The stethoscope clicked at 150 degrees in the lower inner quadrant, but both the cardiophone and the oscillogram were silent except for slight crunching in the lower inner quadrant. (See Figure 16.) Operation showed loose detachment of the anterior half of the internal semilunar cartilage, which seemed to slip in and out without clicking. The click was occasional only, and the operative findings were in harmony with the auditory findings.

CASE 72. J. G., thirty-nine years old, sustained a bucket-handle fracture of the internal meniscus of the right knee. There was a history of repeated locking. The stethoscope was silent, except for fine grating in the lower inner quadrant at terminal positions. The cardiophone seemed to give a dull thud in the lower inner quadrant, with the knee in flexion and in extension, and the oscillogram also showed dull thuds between 120 and 150 degrees in the lower inner and lower outer quadrants. (See Figure 17.) The joint was opened by an internal Jones incision, and a bucket-handle fracture of the internal cartilage was found. The physical examination pointed to the inner cartilage, but the auditory findings were somewhat uncertain.

If we examine the fourteen cases in which operations were performed with resultant cure, we find good correlation of auditory findings. These

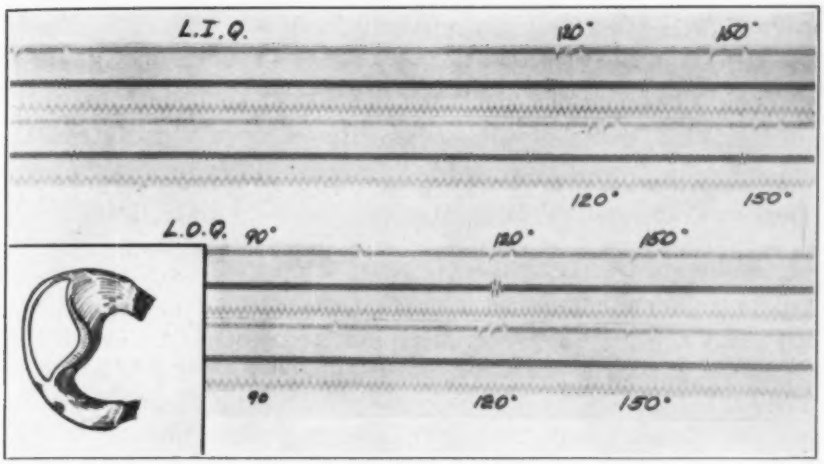


FIG. 17

Case 72. J. G. Preoperative. Injury to the internal semilunar cartilage of the right knee. The stethoscope was silent; the cardiophone recorded a dull thud in the lower inner quadrant; and the oscillogram revealed a dull thud at 120 degrees in the lower quadrants. At operation, through the Jones incision, a bucket-handle fracture of the internal cartilage was found. The auditory findings were somewhat uncertain.

findings were corroborated by operation in eleven cases. In three cases, the correlation between the auditory and the operative findings was poor. It should be noted that auditory findings are missing in cases of fracture of the semilunar cartilages with easily detachable flaps which slip in and out without great impediment.

In the majority of cases the auditory findings were of definite value in indicating not so much the type of lesion as its exact location. They were responsible for the correct choice of the small Jones incision in a number of cases.

Miscellaneous—36 Cases

The remaining cases of this series of 397 knees were classified as follows: ligamentous strain, ten cases (2.52 per cent.); synovitis, five cases (1.26 per cent.); derangement of the fat pads, eleven cases (2.77 per cent.); old fractures of the knee, three cases (0.76 per cent.); and a group which included cases of hygroma and tuberculosis and knees upon which arthroplasties had been performed, seven cases (1.76 per cent.). In this last group there was no tendency to accurate diagnostic values.

COMMENT

This report is, in a manner, preliminary, since it is the first communication on the application of sound phenomena in the locomotor system—muscles, tendons, and joints—for diagnostic purposes. The knee was selected because of its easy accessibility to sound-receiving instruments. The interpretation of sound phenomena is very difficult, because extra-

neous and extra-articular noises must be differentiated from intra-articular ones. However, it is possible to allocate certain sounds as intra-articular, because of their character and also because of the regularity of their occurrence in repeated stethoscopic, cardiophonic, and oscillographic examinations.

Sustained grating or cracking sounds in all quadrants indicate a general involvement of the joint, with arthritic changes which may or may not be the background of isolated internal derangements.

Isolated sounds are cracks, clicks, or thuds. The higher-pitched cracks indicate a harder or denser body, such as a joint mouse, while the lower clicks and the still lower thuds indicate bodies of greater softness and elasticity, such as fringes and semilunar cartilages. While we do not claim to be able to make a definite distinction between the bodies responsible for the sound, we believe that we can locate the origin of the sound both as to quadrants and as to position of the joint. In this respect, joint auscultation is a definite help, particularly in cases of injury to the semilunar cartilages.

The writer is greatly indebted to Mr. E. L. White, who directed the technical arrangement of the experiments and examinations, and also to Mr. P. Griffith, who helped with the oscillographic records. The author also gratefully acknowledges the valuable assistance of his associates, Dr. T. L. Waring, Dr. J. G. Finder, and Dr. D. M. Fuiks, in the compilation of data and in the arrangement of specimens and illustrations.

REFERENCES

Bircher, E.: Zur Diagnose der Meniscusluxation und des Meniscusabrisses. Zentralbl. f. Chir., XL, 1852, 1913.

Blodgett, W. E.: Auscultation of the Knee Joint. Boston Med. and Surg. J., CXLVI, 63, 1902.

Erb, K. H.: Über die Möglichkeit der Registrierung von Gelenkgeräuschen. Deutsche Ztschr. f. Chir., CCXLI, 237, 1933.

Hueter, C.: Grundriss der Chirurgie. 3 Aufl. Leipzig, F. C. W. Vogel, 1885.

Ludloff: Die Auskultation der Wirbelsäule, des Kreuzbeins und des Beckens. Münchener med. Wchnschr., LIII, 1197, 1906.

Walters, C. F.: The Value of Joint Auscultation. Lancet, I, 920, 1929.

ANATOMICAL CONSIDERATIONS RELATIVE TO RUPTURE OF THE SUPRASPINATUS TENDON

BY H. ALAN SKINNER, M.B., F.R.C.S. (C)., LONDON, ONTARIO, CANADA

From the Department of Anatomy, University of Western Ontario

Separation of the supraspinatus from its attachment to the humerus is a condition which has been recorded by various writers, notably by Codman of Boston, who was one of the first to recognize the prevalence and importance of the condition. There has been a general tendency to accept it clinically as the direct result of trauma without inquiring into the possibility of other etiological factors. Observations upon cadavera, in this Department and elsewhere, suggest a more wide-spread disturbance than mere rupture of a muscle.

The fact is that the rupture is very often only an accident in the course of a progressive disturbance which also involves other structures. Thus it is not surprising to find several aspects of the same condition described by different authors under various headings such as simple traumatic rupture, subacromial bursitis, or fracture of the greater tuberosity. Others have been more impressed by the disappearance of the tendon of the long head of the biceps, which so frequently occurs as a concomitant condition; still others have merely recorded the calcification which is often found in the supraspinatus tendon; while only too often the whole disturbance is classed as arthritis. It is the author's belief that a progressive disturbance, centering around the tendon of the supraspinatus, will be found to be sufficient to account for all of the different findings.

The roof of the shoulder joint consists of two very different parts: (1) a fairly stable bony arch lying above the joint; and (2) structures intervening between the arch and the joint, of which the supraspinatus is the most prominent. This muscle is in close relationship with the joint capsule below, but the tendon is separated from the bony arch above by a large subacromial bursa. This tendon is thus caught between the moving head of the humerus below and the acromial arch above, and is protected by and in contact with a synovial cavity on each side. If the tendon should rupture, communication may be established between the joint cavity and the subacromial bursa, thus adding a further complication.

Rupture of the supraspinatus tendon has been frequently recorded, especially by Codman. The disturbed conditions of the shoulder joint which he reported were, in his opinion, due entirely to unrecognized rupture of this tendon. In his experience, based upon the examination of cadavera in the dissecting room, the condition occurs in one out of every twenty subjects. In a later contribution Codman and Akerson reported that in elderly subjects (particularly in working people) the incidence of ruptured supraspinatus tendon was greater,—nearly 40 per cent. In

some cases the rupture was quite small, but in 21 per cent. of the subjects it was sufficient to permit communication between the joint and the subacromial bursa. In one of his more recent articles [3] Codman stated that he believed "that rupture of the supraspinatus tendon is the most common industrial injury causing prolonged shoulder disability . . ." In a recent analysis of cadavera, Keyes [10] reported that 17 per cent. showed partial rupture of the supraspinatus tendon.

Meyer considered the condition to be the direct result of attrition and placed especial emphasis on the disappearance of the tendon of the long head of the biceps in some of these cases. He stated that "whatever the associated conditions may be it would seem that these capsular defects result from repeated and long continued use of the arm in a position of marked abduction and external rotation . . . it would also seem that the irritation and trauma resulting from this friction might bring on a subdeltoid bursitis antecedent to the destruction of this bursa. This unavoidable trauma to the soft parts undoubtedly would also be followed by a protective reaction in the superior portion of the capsule and thus cause thickening of it. However, as soon as the capsule has been worn through near the region of the greater tuberosity, the rough surface of the latter can come in contact with the capsular portion of the long head of the biceps and begin its erosion and final destruction."

Codman and Akerson presented four hypotheses to account for the separation of the supraspinatus from its attachment to the tuberosity: (1) result of trauma (rupture and imperfect repair); (2) defects left by so called calcified deposits; (3) necrosis of tendon or other diffuse pathological process; and (4) direct result of attrition (hypothesis of Meyer).

REPORT OF TYPICAL FINDINGS

The examination of a series of 100 shoulders in the Department of Anatomy of the University of Western Ontario has revealed six cases showing a major disturbance of the anatomical relations sufficient to permit communication between the subacromial bursa and the cavity of the shoulder joint. At least a dozen others showed changes associated with the supraspinatus muscle. A brief account of some of the typical findings follows.

FIG. 1
Specimen 11.

SPECIMEN 11 (Figures 1 and 2). Right shoulder.

This shoulder is an excellent example of a moderately severe dis-

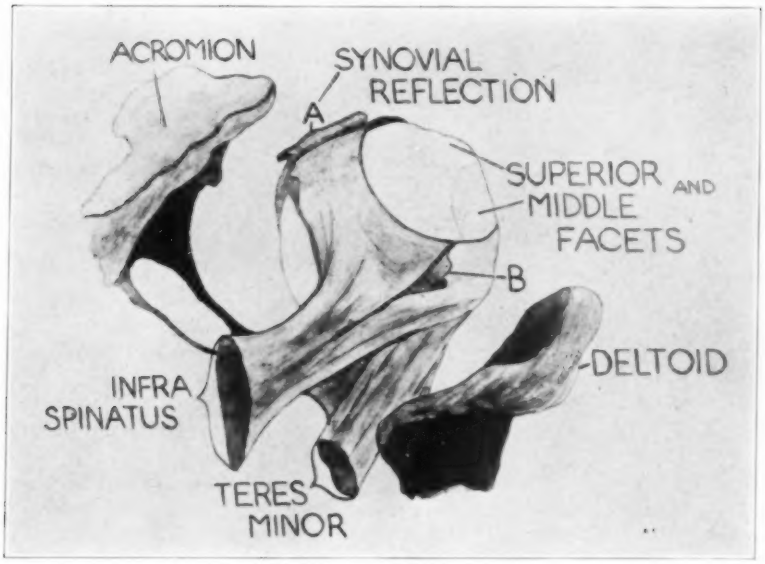


FIG. 2

A diagrammatic drawing of Specimen 11, as shown in Fig. 1. The fibrous band is clearly shown, detached from its medial connection,—*i.e.*, from the supraspinatus. At *A* and *B* can be seen the synovial reflections of the subacromial bursa.

turbance resulting from rupture of the supraspinatus tendon. The subacromial bursa is in free communication with the joint cavity. The supraspinatus ends laterally in a falciform fibrous band which is attached in front to the lesser tuberosity and behind to the posterior aspect of the middle facet on the greater tuberosity. The infraspinatus is partially involved.

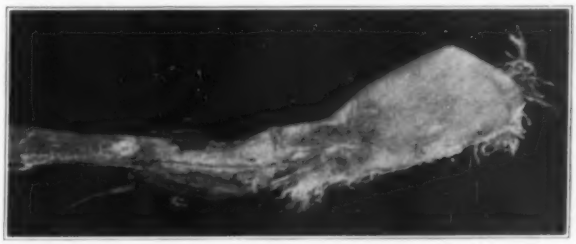


FIG. 3

The tendon of the long head of the biceps removed from Specimen 79. The flattened condition of the upper portion and the fraying of the tendon are clearly shown.

There is no trace of that portion of the long head of the biceps which normally passes over the head of the humerus. The long head of the biceps was found to arise in the upper part of the intertubercular sulcus. It had no apparent connection with the falciform band.

SPECIMENS 78 and 79

These were the right and left shoulders of the same subject. They presented a similar amount of disturbance. The supraspinatus and infraspinatus joined at their insertion by means of an aponeurotic sheet, in the lateral part of which a small V-shaped slit afforded free communication between the subdeltoid bursa and the joint cavity. On the left side the tendon of the long head of the biceps was quite flattened over the head of the humerus and very frayed along the edges (Fig. 3). In addition there were several synovial fringes in the joint, especially one along the biceps tendon. In this

FIG. 4

Specimen 23. The deltoid has been reflected and the bursa opened up. Note the edge of the fibrous band and the irregular appearance of the bone.

specimen, which suggested eventual disappearance of the biceps tendon, particular attention was paid to the condition of the intertubercular sulcus. Here the bone was found to show a number of small depressions or pits to which strands of fibrous tissue passed from the tendon. These small secondary anchorages of the tendon in the sulcus possibly indicate the first steps in the securing of a permanent secondary attachment prior to the disappearance of the upper part of the tendon.

SPECIMEN 23 (Figure 4) Right shoulder.

This is similar to Specimen 11. The upper part of the biceps tendon is gone and the new origin is from a prominent knob on the side of the lesser tuberosity. The illustration shows the general nature of the bony changes taking place around the exposed tuberosities and the intertubercular sulcus, and indicates the increasing difficulty which surrounds the movement of the biceps tendon through the sulcus up to the time of the new secondary attachment and disappearance of the upper portion.

SPECIMEN 28 (Figures 5 and 6). Left shoulder.

This shoulder presented the most extreme example of the disturbance encountered in the series. The subacromial bursa was greatly enlarged and there was no apparent separation between it and the joint cavity. The articular surface of the head of the humerus extended continuously over the greater tuberosity and it was quite apparent that the tuberosity had been articulating with the inferior aspect of the acromion process. This latter showed a smooth, polished surface, about three-quarters of an inch in diameter, on its inferior aspect.

The supraspinatus and infraspinatus muscles ended laterally in a continuous fibrous band which appeared as a falciform fold in the medial wall of the enlarged synovial cavity just above the glenoid lip. This was the greatest amount of retraction of these muscles found in any specimen. The upper portion of the tendon of the long head of the biceps was missing and the head was found arising from the lateral aspect of the lesser tuberosity. The tendon of the subscapularis was thin and small and attached to the inferomedial aspect of the lesser tuberosity. It created a fold in the anterior part of the capsule along which synovial fringes were present.

In addition to these five specimens described, a sixth case, not quite as marked as Specimen 23 but similar in character, was found.

During the examination of the shoulders of this series it was noted that a number of cases exhibited what appeared to be a change from the normal character of the supraspinatus and, to a lesser extent, of the infraspinatus. This change consisted of a loss of the muscular or fleshy nature of the supraspinatus as it passed over the shoulder joint. In these cases

the superior aspect of the shoulder joint appeared to be covered by an aponeurotic sheet into which the supraspinatus and infraspinatus muscles blended. In two cases this sheet was extensive enough to approach the subscapularis tendon on the one side and to involve the teres minor on the other. In two other cases calcified deposits were found in these aponeurotic sheets, near the attachment to the greater tuberosity. The changed character of the muscle tendons in these cases raised the question of the normal condition of the supraspinatus in its relation to the shoulder joint.

FIG. 5
Specimen 28.

ANATOMY AND PHYSIOLOGY

Examination of standard works on anatomy discloses the unqualified statement that the supraspinatus is inserted by a tendon into the upper of the three facets on the greater tuberosity of the humerus. In some texts, no mention is made of any attachment to the capsule of the shoulder joint; in others, it is mentioned; while in some the tendon is said to be intimately attached to the capsule. In the case of the infraspinatus only its insertion into the middle facet is mentioned, and no indication of the possibility of its attachment to the capsule is suggested.

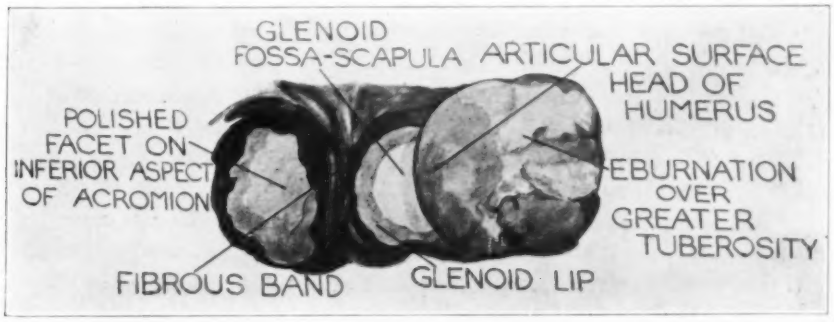


FIG. 6

A diagrammatic drawing of Specimen 28, as shown in Fig. 5. The extreme conditions shown in this specimen represent the end stages of the disturbance. Note the condition of the humerus, especially the area of the greater tuberosity and the polished facet on the under surface of the acromion. Observe also the position of the fibrous band between the acromion and the glenoid lip. This is the band into which the supraspinatus and infraspinatus were inserted.

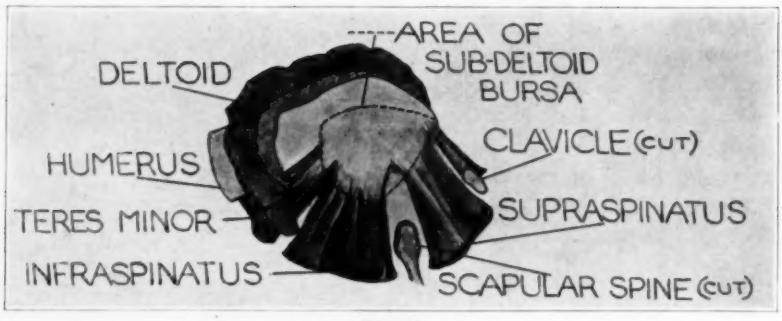


FIG. 7

A diagrammatic drawing illustrating how the insertions of the supraspinatus, infraspinatus, and teres minor may blend together during the first stage, forming an aponeurotic sheet which is closely fused with the capsule of the shoulder joint. The subdeltoid bursa usually extends over the same area, as is shown by the dotted line.

In order to obtain a starting point for the determination of the normal condition of the muscle, a number of shoulders of stillborn infants were examined. These shoulders indicate that the supraspinatus and infraspinatus are normally fleshy right up to the point of insertion, a very short fibrous tendon forming the terminal portion. As older and more mature shoulders are inspected, it becomes increasingly evident that the lateral fibrous portion tends to increase in amount.

The interval between the supraspinatus and infraspinatus is normally filled in with connective tissue, so that no hollow exists between the two tendons. As they become more fibrous, the intervening connective tissue seems to become identified with the fibrous portions of the muscles, and the whole gradually forms a thick aponeurotic sheet over the shoulder joint. This change from a fleshy muscle to an aponeurotic sheet continues until all of the muscle which is in contact with the joint capsule has been altered. Attachment to the joint capsule follows this change and the amount of attachment is directly proportional to the amount of aponeurosis of the muscle insertion. Similarly the area of the subacromial bursa appears to follow the spread of the aponeurotic portion of the muscle, so that the area of the bursa is practically that of the fibrous sheet. The findings of the dissecting room thus suggest a progressive change in the character of that part of the muscle which lies in contact with the joint capsule. This change produces an aponeurotic sheet which is closely connected with a synovial cavity above and below. (See Figure 7.)

The attachment of this sheet to the greater tuberosity appears to be a matter of some variation, depending on the size of the sheet. It may include both the superior and middle facets or only a portion of them. The attachment may be reduced to a line along the outer edge of the tuberosity. When the attachment is more lateral, the synovial lining of the joint tends to follow as far as possible, so that a portion of the greater tuberosity may become covered by synovial membrane.

In order to comprehend what has been happening to the supraspi-

natus muscle we must turn to a consideration of its physiology, for function is the determinative factor in structure.

From the position of the supraspinatus, it is evident that it is conveniently placed to assist in the movement of abduction. According to various writers the muscle is concerned with the first stage of abduction only, raising the arm some 15 or 20 degrees. Codman and Stevens agree that the first stage of abduction is due to the supraspinatus, but Stevens considers that it acts through about 30 degrees. The deltoid then continues the movement, being incapable of initiating the movement of abduction. In support of this we have been referred to a patient suffering from a stab wound which severed the nerve supply to the supraspinatus. This individual was subsequently unable to initiate the movement of abduction in the usual way (although the deltoid was uninjured) and had to resort to one of two expedients,—by bending the trunk and swinging the arm or by giving the arm a push with the other hand, he got it out to the point where the deltoid was able to carry on.

From the standpoint of leverage, it may be pointed out that the supraspinatus has less and less advantage as abduction proceeds and that it would, therefore, be at its best during the early stages. During these early stages of abduction, the reverse is true of the deltoid. It has no angle of leverage at all with the arm at the side. The action of the deltoid at this stage would, therefore, be a pull in the direction of the long axis of the humerus. This would bring the upper end of the humerus against the acromial arch and compress the intervening supraspinatus. Thus the supraspinatus is pulling medially between two bony surfaces which are compressing it at the same time. If this continual "ironing" or "rolling" takes place frequently and over a long time, or if it is accompanied by additional pressure, it must in time have a profound effect upon the tendon.

Several protective mechanisms operate to protect the supraspinatus. In the first place, the large and constant subacromial bursa intervenes between the supraspinatus and the bony arch above. This bursa acts as a cushion against the upward thrust of the humerus. Once the supraspinatus has passed medially, the bursa continues to act between the tuberosity and the acromion. In connection with the bursa there has been an almost constant finding of a fibrous expansion from the tendon of the short head of the biceps which occupies the angle between the short head of the biceps and the coraco-acromial ligament. This serves to strengthen the superior wall of the bursa. The long head of the biceps may have some part in opposing the upward thrust of the humerus.

There must be noted also the action of the short rotators as pointed out by Stevens. As the movement of abduction progresses, the short rotator muscles (subscapularis, infraspinatus, and teres minor) acting together resist the upward thrust without affecting the direction of the movement (since the sum of the pull of the lateral rotators balances the sum of the medial). Martin has stated that the latter stage of abduction is accompanied by some lateral rotation of the humerus, but he considers

it to be due to the contact of the tuberosity with the under surface of the acromion.

FURTHER STRUCTURAL DISTURBANCES

The gradual change in the supraspinatus from the fleshy character of the infantile muscle to the aponeurotic insertion of the middle-aged might possibly be considered as a normal alteration due to use. However, it brings about several secondary changes which cannot be considered as normal. Moreover the change in the supraspinatus is probably not developed quickly except under conditions of frequent abduction or continued pressure. Some of the other changes will be discussed briefly.

Fusion of Aponeurosis and Joint Capsule

The protection of the superior aspect of the joint capsule having been diminished by the thinning of the related portion of the supraspinatus and its change from a fleshy character to an aponeurosis, there is invariably a fusion of the aponeurosis with the capsule. One result of this fusion is that the capsule is drawn medially by the action of the supraspinatus during abduction, so that there is little chance that the capsule would be nipped or pinched in a fold. If the fusion did not occur, it is probable that a small bursa would be formed between the joint capsule and the aponeurosis. Such a bursa has been described, but the author has never seen it; in all of his cases fusion was complete.

Calcified Deposits in the Aponeurotic Sheet

Calcified deposits have been frequently observed by various authors in the aponeurotic tendon close to the greater tuberosity. These may be identified in roentgenograms and, if close to the tuberosity, they may be mistaken for slight fractures of the tuberosity. Codman and Wright studied the pathology of these calcified deposits and came to the conclusion that they resulted from slight injuries to the tendon with an abortive attempt at repair in a tissue possessing but little blood supply. Brickner and Moschowitz arrived at a similar conclusion[1]. Elmslie agreed that this was the most likely explanation. Carnett, after opening fourteen shoulders with calcified deposits, recorded his impression that in none of his cases was it due to rupture of the tendon fibers. Harbin, in discussing calcium salts in tendons, noted that the blood supply of the tendon was poor and considered it probable that frequently repeated mild trauma might occur as the result of impingement of the tendon against the inferior surface of the acromion during abduction, with resulting necrosis and calcification. He further noted examples cited by Schujenioff who found lime salt deposited in muscle fibers thirty-six hours after suture of a divided muscle. Harbin was definitely of the opinion that severe trauma was not the cause of the condition.

The deposits of calcium may be single or multiple and may be unilateral or bilateral (Carnett). They vary in size and may occupy different

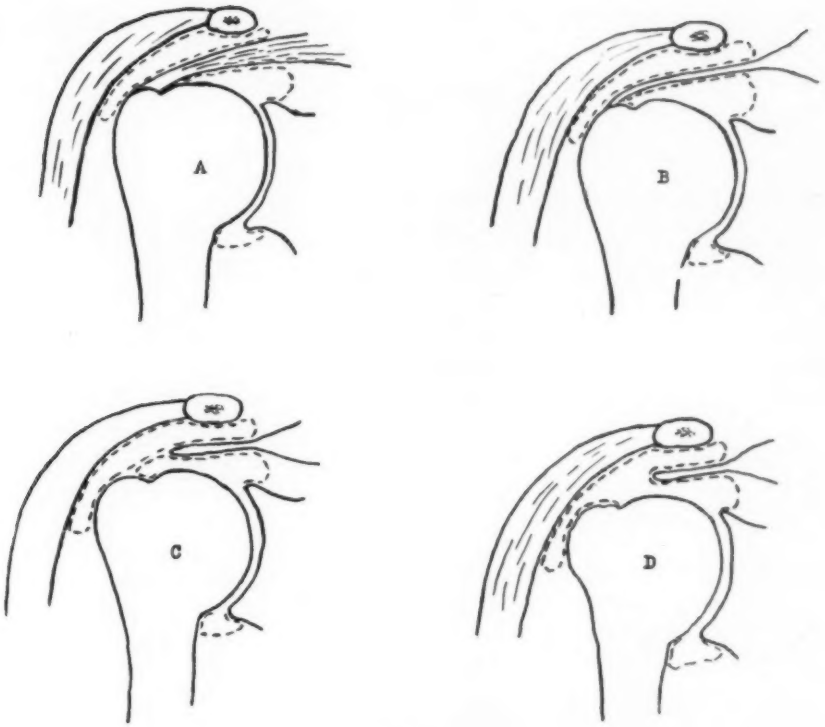


FIG. 8

Diagrammatic drawings representing four stages in the development of the condition:
A: Normal;
B: Aponeurotic sheet fused with capsule;
C: Separation of the aponeurotic sheet from the tuberosity;
D: Communication established between the joint cavity and the bursa.

positions. In the shoulders examined in this series, calcified deposits were found only twice, and in both cases the insertion of the supraspinatus was in the form of an aponeurotic sheet. The deposits were both close to the attachment to the tuberosity.

It is suggested that these calcified deposits occur at a definite period in the development of the condition which is under consideration. They occur after the creation of the aponeurotic sheet at a time just antecedent to that when separation of the fibers is likely to occur. Codman and Akerson suggested that the disappearance of calcium deposits was one of the possible ways for defects in the tendon to occur.

Disappearance of the Tendon of the Long Head of the Biceps

The same causes which have operated to produce changes in the supraspinatus have undoubtedly had their effect upon the tendon of the long head of the biceps. The tendon from Specimen 79 (Fig. 3) illustrates the first stage. The tendon becomes flattened, thin, and frayed along its edges. As the tendon weakens, secondary attachments are formed in the

intertubercular sulcus, so that when the upper part eventually disappears a new attachment is ready. The third and final stage of disappearance of the capsular portion of the tendon is probably not completed until communication is established between the joint cavity and the subacromial bursa.

Rupture of the Aponeurotic Tendon

It matters little whether separation of the aponeurotic insertion of the supraspinatus occurs as a result of previous calcification, splitting of the fibrous sheet, or sudden rupture due to trauma. The essential point which the writer wishes to make is that the formation of the aponeurotic sheet is a preliminary stage antecedent to separation. Once separation has occurred, the continued action of the supraspinatus will obviously cause the defect to increase and, as the synovial lining of the joint cavity and the subacromial bursa come into contact, the pressure effect will soon break down the partition and create a condition of free communication between joint and bursa. (See Figure 8.)

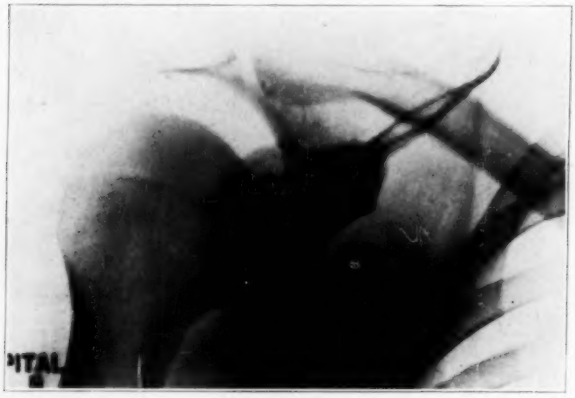


FIG. 9-A

FIG. 9-B

A normal shoulder in a young adult male.

At first there is some fibrillation and shredding of the tendon with irregular tags of fibrous tissue remaining attached to the greater tuberosity. Gradually these shreds of tissue are absorbed and disappear, and the free edge of the retracting supraspinatus tendon becomes smooth and regular and presents a falciform edge, the horns of which are attached anteriorly and posteriorly to extremities on the greater tuberosity. (See Figures 1 and 2.) In Specimen 28, the most extreme example of this condition, all connection of the supraspinatus with the tuberosity has been lost.

Bony Changes

The most marked bony changes occur in that portion of the greater tuberosity which has been laid bare by the retraction of the supraspinatus. The bony surface becomes rough, irregular, and pitted. If the condition proceeds to the extreme represented by Specimen 28, this surface of the greater tuberosity may become smooth again, due to rubbing against the under surface of the acromion.

FIG. 10

The shoulder of a painter, showing some change in contour of the greater tuberosity and lessening of the interval between the humerus and the acromion. Compare with Figs. 9-A and 9-B. Note also absorption shadows in the region of the greater tuberosity.

As might be expected, the bony changes which take place in the greater tuberosity and in the intertubercular sulcus are often reflected on dried and disarticulated bones. Examination of seventy humeri in the Department of Anatomy gave the following results:

Normal	48 cases
Changes in tuberosity alone	12 cases
Changes in sulcus alone	2 cases
Changes in both	5 cases
Changes obviously due to arthritis	3 cases
Total	70 cases

It will be observed that the majority of changes were noted in the region of the greater tuberosity and that this area was affected seventeen times in the seventy bones. This is an occurrence of about 24 per cent. In the bones where changes were present both in the tuberosity and in the sulcus, it was quite apparent that the upper part of the tuberosity had been unoccupied and that no tendon of the biceps could possibly have been working through the intertubercular sulcus.

ETIOLOGICAL FACTORS

The condition appears to be a gradual and progressive change centering about the supraspinatus muscle and the movement of abduction. Several factors combine to produce this effect. Since the condition is primarily associated with the movement of abduction, there is an occupational factor when the individual is engaged in an activity which requires frequent abduction or which necessitates working with the arm in an ab-

FIG. 11
Specimen 28.

ducted position. Another factor would be continued pressure such as occurs in the act of scrubbing a floor.

Since time is required to develop the changes which are necessarily antecedent to separation, the condition is not liable to occur in young people. Codman stated that he had never found a rupture of the supraspinatus tendon in a patient under twenty years. The average age in his series of 122 was fifty-three years. The average age of the six cases reported here could not be determined exactly; it lay between fifty-five and sixty. These figures apply to the cases where progressive change preceded separation. It is possible, of course, for direct violence to rupture any muscle, the supraspinatus not excepted. Fractures of the greater tuberosity also occur as a result of direct violence. This type of injury is not within the scope of this paper.

In the history of these cases there may or may not be a history of injury. Where thinning of the tendon has taken place, it is possible to have either partial or complete separation with a very small amount of violence. Where a history of injury is obtained, it is usually definitely associated with abduction, as, for instance, in the case of a woman throwing a heavy wet blanket over a line. Wilson recorded the case of a man who ruptured the supraspinatus by throwing a heavy stone out of a trench. Definite histories of this type are, however, uncommon. Many cases occur during a fall or misstep when the patient throws up an arm to retain his balance or to seize some support. The occupational history is important. Wilson reported the case of a patient who was engaged in folding heavy woolen cloth, a task necessitating abduction and external rotation of the right shoulder. He had performed this task many times daily during a period of six years.

PHYSICAL DIAGNOSIS

While the history is of great importance in making a diagnosis, there are one or two physical signs which may be noted. First, there is Dawbarn's sign. This sign is present in any case which presents a tender point over the greater tuberosity. Thus fracture, bursitis, and rupture of the supraspinatus tendon may all present this diagnostic sign. It consists in disappearance of the tender point in full abduction, due to the fact that the painful part has been carried in under the acromion process. Fracture

of the tuberosity may be eliminated by roentgenographic examination. In acute bursitis, active and passive abduction are both painful; in rupture of the supraspinatus, passive abduction is less liable to cause pain.

A later sequela in more pronounced cases may be represented by partial atrophy of the supraspinatus and infraspinatus. This has been described by Codman and results in increased prominence of the spine of the scapula.

A point which may be recalled at this time is that the condition is sometimes bilateral. This is difficult to explain on the basis of injury alone without previous change in the supraspinatus.

The rôle of the roentgenographic examination in the diagnosis of this condition, while not conclusive, is nevertheless of considerable importance. As has already been noted, it is necessary in differentiating this affection from fracture of the greater tuberosity. Direct results of attrition, however, may be noted under three heads.

The first thing to look for is the occurrence of calcified deposits in the insertion of the supraspinatus. Such deposits are direct evidence of the presence of the progressive change which leads to separation.

The second and more constant finding to be watched for is the occurrence of slight absorption shadows and irregularities in the greater tuberosity itself. (See Figure 10.) Such shadows have been found in both suspected and proved cases. They usually consist of one or two small dark areas of absorption near the crest of the greater tuberosity. Their occurrence is very significant. In extreme cases the roentgenographic findings are very definite as there is a change in the entire contour of the upper end of the humerus. (See Figure 11.)

The third point to be looked for in the roentgenograms is the amount of interval existing between the head of the humerus and the acromion. In order to make any accurate comparison of this interval it is necessary to work out an exact technique, so that the same relative angle may be employed in all cases. It is also important to compare both shoulders. Thinning or disappearance of the intervening supraspinatus muscle of course reduces the interval.

TREATMENT

It is not the purpose of this article to discuss treatment in detail. In the earlier stages the value of local treatment should be debated, especially horizontal splintage to provide rest for a weakened tendon. No method of local treatment, however, will be completely successful if there is an occupational factor which has been disregarded.

Various forms of operative procedure have been discussed by Codman, Carnett, Harbin, Wilson, and Fowler, and probably by many others. Operative procedures as described seem more applicable to acute traumatic rupture of an unimpaired tendon than to cases with a chronic background. The possibility of reparative procedures in those old cases where

fibrous change in the tendon has been followed by rupture and retraction is something to be debated by the surgeons.

SUMMARY AND CONCLUSIONS

The normal anatomical relations and the physiological action of the supraspinatus muscle in the movement of abduction are such that frequent and continued action may produce a profound change in the character of the muscle.

The change in the muscle consists essentially of an alteration in the character of its lateral portion,—from fleshy fibers ending in a short tendon to a wide aponeurosis of fibrous tissue which blends with the infraspinatus.

Once the muscle has been weakened by this alteration, a series of other changes become imminent possibilities. These include calcification, splitting or rupture of the tendon, separation of the sheet from the greater tuberosity, and the establishment of free communication between the subacromial bursa and the joint cavity.

Associated and subsequent changes occur in the greater tuberosity, in the intertubercular sulcus, in the articular cartilage, in the tendon of the long head of the biceps, and in the walls of the joint cavity.

The long head of the biceps (capsular portion of the tendon) is at first flattened and frayed. Eventual disappearance of this portion is not uncommon.

The purpose of this communication is to emphasize the fact that these results are not caused by sudden acute ruptures of the supraspinatus, but are preceded by a long preliminary wearing effect on the tendon of the supraspinatus. On this account the age of the patient and the type of occupation are important etiological factors.

From all figures available it would appear that about 20 per cent. of all adult shoulders show some degree of change in the supraspinatus. Further, about one-quarter of this 20 per cent. will suffer some degree of rupture or splitting. On this basis, the condition as described constitutes the most common form of shoulder disability. Comparison of these figures with the number of cases reported suggests that many of these shoulders are undiagnosed and untreated.

The author wishes to express his thanks to the X-Ray Department of Victoria Hospital, London, for their assistance.

REFERENCES

1. Carnett, J. B.: The Calcareous Deposits of So-Called Calcifying Subacromial Bursitis. Surg. Gynec. Obstet., XLI, 404, 1925.
2. Codman, E. A.: Some Points on the Diagnosis and Treatment of Certain Neglected Minor Surgical Lesions. Boston Med. and Surg. J., CL, 371, 1904.
On Stiff and Painful Shoulders. The Anatomy of the Subdeltoid or Subacromial Bursa and Its Clinical Importance. Subdeltoid Bursitis. Boston Med. and Surg. J., CLIV, 613, 1906.
Bursitis Subacromialis, or Peri-Arthritis of the Shoulder-Joint

(Subdeltoid Bursitis). Boston Med. and Surg. J., CLIX, 533, 576, 615, 677, 723; 1908.

Complete Rupture of the Supraspinatus Tendon. Operative Treatment with Report of Two Successful Cases. Boston Med. and Surg. J., CLXIV, 708, 1911.

"On Stiff and Painful Shoulders" as Explained by Subacromial Bursitis and Partial Rupture of the Tendon of the Supraspinatus. Boston Med. and Surg. J., CLXV, 115, 1911.

Obscure Lesions of the Shoulder; Rupture of the Supraspinatus Tendon. Boston Med. and Surg. J., CXCVI, 381, 1927.

3. CODMAN, E. A.: Rupture of the Supraspinatus Tendon. Surg. Gynec. Obstet., LII, 579, 1931.
4. CODMAN, E. A., AND AKERSON, I. B.: The Pathology Associated with Rupture of the Supraspinatus Tendon. Ann. Surg., XCIII, 348, 1931.
5. DAWBARN, R. H. M.: Subdeltoid Bursitis: A Pathognomonic Sign for Its Recognition. Boston Med. and Surg. J., CLIV, 691, 1906.
6. DUCHENNE: Quoted by Sir Robert Jones and R. W. Lovett *in* Orthopedic Surgery. New York, William Wood & Co., 1923.
7. ELMSLIE, R. C.: Calcareous Deposits in the Supraspinatus Tendon. British J. Surg., XX, 190, 1932.
8. FOWLER, E. B.: Rupture of Spinati Tendons and Capsule, Repaired by a New Operation. Illinois Med. J., LXI, 332, 1932.
9. HARBIN, MAXWELL: Deposition of Calcium Salts in the Tendon of the Supraspinatus Muscle. Arch. Surg., XVIII, 1491, 1929.
10. KEYES, E. L.: Anatomical Observations on Senile Changes in the Shoulder. J. Bone and Joint Surg., XVII, 953, Oct. 1935.
11. KEYES, E. L.: Observations on Rupture of the Supraspinatus Tendon. Based on a Study of Seventy-Three Cadavers. Ann. Surg., XCVII, 849, 1933.
12. MARTIN, C. P.: A Note on the Movements of the Shoulder-Joint. British J. Surg., XX, 61, 1932.
13. MEYER, A. W.: Spolia Anatomica. 12. Bilateral Absence of the Tendon of the Long Head of the Biceps in One Subject, and Five Instances of Secondary Attachment of the Tendon to the Articular Capsule and Tuberosities, with Special Reference to the Effect of These Anomolous Conditions upon the Intertubercular Sulcus. J. Anat. and Physiol., XLVIII, 133, 1913–1914.

Unrecognized Occupational Destruction of the Tendon of the Long Head of the Biceps Brachii. Arch. Surg., II, 130, 1921.

Further Observations upon Use-Destruction in Joints. J. Bone and Joint Surg., IV, 491, July 1922.

Further Evidences of Attrition in the Human Body. Am. J. Anat., XXXIV, 241, 1924.

Spontaneous Dislocation of the Tendon of the Long Head of the Biceps Brachii. Report of Four Cases. Arch. Surg., XIII, 109, 1926.

Spontaneous Dislocation and Destruction of Tendon of Long Head of Biceps Brachii. Fifty-Nine Instances. Arch. Surg., XVII, 493, 1928.

14. STEVENS, J. H.: The Action of the Short Rotators on the Normal Abduction of the Arm, with a Consideration of Their Action in Some Cases of Subacromial Bursitis and Allied Conditions. Am. J. Med. Sciences, CXXXVIII, 870, 1909.
15. WILSON, P. D.: Complete Rupture of the Supraspinatus Tendon. J. Am. Med. Assn., XCVI, 433, 1931.

TENDINOPLASTY OF THE FLEXOR TENDONS OF THE HAND

Use of Tunica Vaginalis in Reconstructing Tendon Sheaths *

BY CLIFFORD LEE WILMOTH, M.D., F.A.C.S., DENVER, COLORADO

One of the difficult problems in surgery of the extremities is the restoration of motion to a hand, following injury to the flexor tendons of the fingers. The use of foreign material to form a sheath in an attempt to prevent adhesions between the tendon and its adjacent tissues has not met with success. Cargile membrane, silver foil, oily pastes, segments of veins, and fascia lata have alike proved unsuccessful. More success has followed the use of tunica vaginalis as a transplant to form a new tendon sheath similar in structure and function to the normal tendon sheath. Unfortunately this autotransplant is available only in males.

The tunica vaginalis is a thin, membranous structure made up of two layers,—the inner one, formed by a single layer of flattened endothelial cells, and the outer one, composed of fibrous connective tissue containing elastic fibers. The presence of the elastic fibers permits the distention of the tunica vaginalis to a marked degree. This thin membrane is easy to work with when held by sutures at the four corners. It is strong and elastic, and apparently, when transplanted, retains its ability to secrete a serous fluid. Unfortunately, like the peritoneum, it tends to form adhesions where it is traumatized. Fortunately, however, the elastic fibers permit movement of the underlying tendon even in the presence of moderate adhesions. In this respect, tunica vaginalis differs from fascia lata or other types of membranous transplants which are not elastic.

The serous lining of endothelial cells of the tunica vaginalis apparently secretes a fluid when transplanted, just as it does *in situ*, when traumatized, by the formation of a hydrocele. It is likely that the fluid aids in preventing adhesions between it and the tendon which it surrounds. It probably also acts as a lubricant to the sliding tendon. Unfortunately, it is not capable by itself of preventing the formation of adhesions, so that active motion of the finger must be started early. Adhesions form very quickly in traumatized peritoneum, and it is probable that they form as quickly in transplanted tissues of identical structure. For this reason, the fingers must not be splinted, but should be mobilized the second day after operation. If a splint is applied to the dorsum of the forearm and hand, holding the wrist in flexion, and if the tendons have been carefully sutured with silk, passive motion without force in the direction of flexion may be started immediately after operation in order to prevent limiting

* The cases included in this paper are from the United States Public Health Service, Division of Marine Hospitals. The experimental work was done at the University of Maryland School of Medicine and College of Physicians and Surgeons.

adhesions. As soon as the incisions are healed, hydrotherapy, followed by active and passive motion, may help to prevent stiffness and may aid in the loosening up process which is invariably required in all cases of tendon suture.

During the course of other experiments on dogs, the tunica vaginalis was removed from the testicle and placed about the tendon of the leg to form a tendon sheath.[2] The newly formed tendon sheath was sutured to the paratenon, encircling the tendon loosely. The secreting layer of tunica vaginalis was placed next to the tendon. This operation was performed on five dogs and they were observed for a period of four months. It was found that the transplanted tunica vaginalis lived and grew although not without adhesions to the tendon. Adhesions formed, although the dogs were permitted to walk on the operated legs from the time of the operation. As far as could be determined, the adhesions did not tend to limit the motion of the tendons.

In the human being tunica vaginalis was first used in 1929 to reconstruct a tendon sheath. In this case, the patient had a badly lacerated hand; the flexor tendons of the second and third fingers had been cut and infection had followed. When seen by the author, the case was of some months' standing. The tendons had not been sutured at the time of injury. At operation, through a lateral incision, it was found that no tendon sheaths remained in the fingers and that the tendons had contracted into the palmar region. The flexor digitorum profundus was reconstructed and tunica vaginalis, the length of the finger, was used for reconstruction of the tendon sheath. The technique for the tendon repair was that advocated by Bunnell.

For the removal of the tunica vaginalis a high incision is made just below the external inguinal ring. The testicle is made to present through this incision. If four sutures of silk are placed in the tunica vaginalis near the line of proposed incision, before it is removed from the testicle, it can be handled with more ease and with less trauma than is possible with the use of forceps. It should be remembered that wherever the membrane is traumatized by forceps there is potential danger of the formation of adhesions.

In difficult cases with destruction of the tendon sheaths and with adherent roughened tendons, it has frequently seemed advisable in the past to excise this roughened adherent tendon and to suture in its place a transplanted tendon. With the use of a smooth, secreting, transplanted tendon sheath, it is believed that many of these roughened tendons can be carefully dissected free and made to function again without resorting to the more difficult operation of tendon resection and tendon transplantation. For the average case, sufficient tunica vaginalis may be removed from one testicle to reconstruct the tendon sheaths of two fingers. The size of the piece which can be removed varies of course with the size of the testicle. A piece, two by two and a half inches, can usually be obtained without previous distention of the tunica vaginalis.

The tunica vaginalis was cut so that it could be inserted below the tendon and between the pulleys. It was sutured laterally with interrupted silk. The tunica vaginalis was then brought over the tendon and the edges were sutured together with interrupted silk, which also anchored it to the subcutaneous tissues of the fingers. (See Figure 1.) A sufficient number of sutures were placed so that as far as possible the tunica vaginalis would be in contact with the subcutaneous tissues of the finger and not with the tendon, so that it would adhere and derive its new blood supply from the subcutaneous tissues. The diameter of the newly formed sheath was approximately twice the diameter of the tendon. The secreting serous layer was turned in toward the tendon.

The results were satisfactory, although it was evident that some adhesions had formed; however, with continued use of physiotherapy, these adhesions did not permanently limit motion.

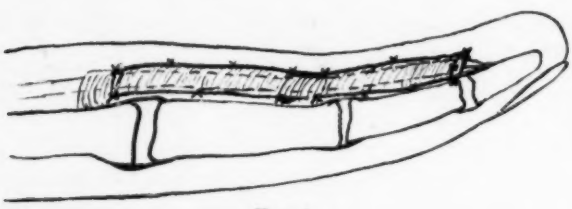


FIG. 1

Reconstruction of the tendon sheath through lateral incisions in the finger. The new sheath of tunica vaginalis is anchored to the soft tissues by interrupted silk sutures.

Since this case, tunica vaginalis has been used in six patients with good results.

CASE 1. The patient was a male, twenty-eight years old, who, some months previously, had received an injury to the right hand, which had severed the flexor tendons of the second and third fingers. The injury was followed by a severe infection. At the time of operation there was loss of function of the flexor tendons of the two fingers. The joints had been kept in fair condition by daily movements, and the blood supply to the injured fingers had not been impaired. After repair of the tendons, the sheath was reconstructed with tunica vaginalis. Motion was started on the third day and was continued as long as progress was made. The final result was a range of motion from full extension to a degree of flexion, so that an object the size of a broomstick could be grasped firmly by the injured fingers. This is a loss of approximately 20 per cent. from the normal range of flexion.

CASE 2. A male, twenty-two years old, had received an injury to the right index finger six months previous to admission. The flexor tendon had been cut and a severe infection had followed. The cut tendon was reconstructed and the tunica vaginalis was removed from the right testicle to form the new tendon sheath. Motion was started on the third postoperative day. The final result was a range of motion from full extension to moderate flexion, with a loss of flexion in the two phalangeal joints, amounting to about 25 per cent.

CASE 3. A male, twenty-four years old, four months previously, had received a lacerated wound of the third finger of the right hand with subsequent infection. He had been unable to flex the middle finger since the injury. After the tendon had been sutured, a sheath was reconstructed from tunica vaginalis removed from the right testicle. The final result was a range of motion from full extension to nearly complete flexion.

CASE 4. A male, thirty-eight years old, had received a severe injury to the right hand, necessitating the loss of the fourth and fifth fingers and the tips of the second and third fingers. The tendons of the second finger were lacerated. There was loss of

FIG. 2
Case 5. Extent of the grafted area.

FIG. 3
Case 5. Full extension of fingers.

flexion in the second finger and very little motion was present in the third. After repair of the flexor tendon of the index finger, the sheath was reconstructed from tunica vaginalis. The results were fair,—a range of motion from full extension to about 50 per cent. of normal flexion.

CASE 5. A male, thirty-six years old, in childhood had suffered a severe burn of the hand, resulting in the loss of the terminal phalanges of the little finger. The third, fourth, and fifth fingers had grown to the palm of the hand. After the fingers had been freed from the scar, and after the tendons had been lengthened at the wrist, a pedicled skin flap from the abdomen was used to cover the denuded area of the palm and fingers. The result was satisfactory except that there was little motion in the fingers, due to the long period of fixation necessitated by the skin grafting. Later, the skin graft was elevated, the tendons were freed, and the tendon sheaths were reconstructed from the tunica vaginalis. The results are shown in Figures 2, 3, and 4.

FIG. 4
Case 5. Full flexion of fingers.

CASE 6. A male, twenty-three years old, had received an injury to the middle finger of the right hand, resulting in inability to flex the finger. Two months after the infection had subsided, the tendon was repaired and the sheath was reconstructed from tunica vaginalis. Motion was started on the third postoperative day. The final result was a range of motion from full extension to nearly complete flexion.

The author has not found that reconstruction of tendon sheaths from tunica vaginalis is ideal, but he believes that it is superior to other materials which have been used.

SUMMARY

The restoration of function to a hand with adherent or destroyed

flexor tendons and tendon sheaths is difficult and often unsatisfactory. Foreign materials, used to form a sheath or to prevent adhesions, have not been found satisfactory. In the finger there is not room for a free transplant of paratendinous fat which has been used with success in other locations.

For the reconstruction of a tendon sheath, tunica vaginalis is superior to other tissues which have been used. Histologically and functionally it resembles the thin, secreting membrane which normally encloses the flexor tendons of the fingers. Early motion is as essential as careful suturing in the reconstruction of flexor tendons and tendon sheaths.

REFERENCES

1. Bunnell, Sterling: Repair of Tendons in the Fingers. Surg. Gynec. Obstet., XXXV, 88, 1922.

Reconstructive Surgery of the Hand. Surg. Gynec. Obstet., XXXIX, 259, 1924.

2. Wilmoth, C. L.: Tunica Vaginalis in Arthroplasty of Small Joints. J. Bone and Joint Surg., XVIII, 165, Jan. 1936.

ARTHROTOMY FOR INTERNAL DERANGEMENT OF THE KNEE *

BY PAUL PLUMMER SWETT, M.D., HARTFORD, CONNECTICUT

That there is no universal standard of management in the operative treatment of internal derangement of the knee is conclusively demonstrated by the wide variation in the ten articles on the subject, by writers from different countries, which were published in *The Journal of Bone and Joint Surgery* for April 1932. It is the object of this paper to report upon the method which the author has consistently followed for several years. It is not intended to add to the confusion, but it is hoped that this modest series of cases treated along definite lines may show that this procedure, consistently adhered to and meticulously carried out, may be looked upon as one example of a standard method.

This plan of operative treatment is based upon certain clear-cut principles, designed to secure the maximum of benefit by emphasizing rigid asepsis, adequate exposure of the knee joint, and non-meddlesome postoperative care.

ASEPSIS

The leg is shaved from the foot to the groin the afternoon before the operation. The entire shaved area is then scrubbed with soap and water and with alcohol. Sterile towels are next loosely bandaged around the extremity and left in place until the patient is anaesthetized. No attempt is made to sterilize the skin below the ankle, because it is liable to prove a source of contamination. The foot, of course, is well cleaned.

After the patient has been anaesthetized, the operator, or a competent assistant, who has been scrubbed, masked, and gloved, scrubs the leg from the ankle to the groin with benzine. He then wipes off the benzine with dry sterile gauze and paints the area with a 4-per-cent. tincture of iodine, which is left on. A sterile sheet is laid under the leg up to the groin, and the foot is wrapped in a sterile towel, which is secured by a thick, wide, gauze spica bandage, extending from the toes to the tibial tubercle. Another sterile sheet is draped over the patient, from the knee to the neck, and this sheet is clipped, on each side of the leg just above the knee, to the sheet upon which the leg lies.

The foot of the table is then dropped to allow the knee to flex to a right angle. The operator seats himself on a stool at the foot of the table, so that the patient's foot is easily supported on the operator's thigh, permitting him to increase or to decrease the flexion of the patient's knee without touching it with his hands,—merely by shifting the position of his own thigh and leg. An assistant stands at each side of the table, facing the knee laterally.

* Read by title at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 21, 1936.

The skin incision is made; the bleeders are picked up without sponging; and the skin towels are applied, so that no skin is exposed to the sight or to the touch. The soft-tissue layers are opened down to the synovial layer by sharp dissection, using ordinary gauze wipes, applied by hand. After the synovial layer has been reached, all further sponging is done with small, dry, compact, gauze sponges which are picked up by the nurse with artery forceps and handed to the operator without letting the wipe come into contact with anyone's hand. At the risk of possible irritation, dry wipes are preferred to wet sponges which require squeezing. At no time is anything put into the knee except these sponges or the instruments, and rarely, if ever, are ties used inside the joint. The exposure is planned to permit adequate visibility and to give space for the required manoeuvers without trauma to the tissues. As soon as the corrective procedure has been completed, the synovial layer is closed with a continuous No. 1 chromic suture, and a small, thin, rubber tissue drain is left just within the joint at the lower end of the incision. The drain is used to prevent the accumulation of an extensive blood clot. It is thought to be safer to do this than to prolong the procedure within the joint by a too protracted effort to stop all the oozing. The free end of the drain is secured by a safety pin, and this is caught through a slit in the wide and long first layer of the gauze dressing which is wet with alcohol. At the end of forty-eight hours, the drain is easily removed by lifting off this dressing; usually, it is not even necessary to touch the drain with the forceps in removing it.

EXPOSURE

Adequate exposure is taken to mean such access to the knee joint as permits full visibility of the lesion or lesions, exploration of all parts of the joint, and room to deal with such lesions as are found. These objects are attained by an incision at the antero-internal aspect, parallel to the patella tendon, beginning slightly above the level of the tibial tubercle and about an inch medial to it, and extending upward slightly medial to the patella to about the level of the middle of the patella. This incision is customary, regardless of the expected lesion, except in the rare cases of a loose body, which is known to be solitary and which can readily be located and dependably localized at some particular place. Through this incision, then, one is able to explore the internal meniscus, the medial joint margins, the infrapatellar pad, the alar ligaments, the crucial ligaments, and the under surface of the internal condyle. If in these locations there is found pathology sufficient to account for the patient's signs and symptoms, no further exposure is required. If, however, no lesions in these regions are found, or if there is any doubt about their adequacy to explain the symptoms, the incision is extended upward along the medial border of the patella and the quadriceps tendon for a distance sufficient to permit a lateral displacement of the patella to the outer side of the external condyle. This exposure affords a comprehensive view of

the external condyle, the external meniscus, and the outer part of the tibial head.

POSTOPERATIVE CARE

The postoperative plan begins with the closure of the skin incision, and the first step is to support the knee firmly without immobilizing it. For this purpose, bulky bandages of folded gauze—about sixteen layers deep, six inches wide, and from four to eight yards long—are snugly wound around the knee in a figure-of-eight, extending from the midleg to the midthigh. The lower extremity is supported over a firm pillow, laid lengthwise under the leg and thigh, so as to permit about 10 degrees of flexion at the knee. The patient is then returned to a bed made rigid by a fracture board, so that the springs cannot sag. The importance of a rigid bed can hardly be overestimated, since it permits the patient to relax more completely, thus preventing painful spastic contractions of the thigh muscles.

From this time on, the patient is permitted to move the knee at will; no passive movements are permitted, and no schedule of voluntary movement is ordered, except that active contraction of the quadriceps is permitted and encouraged as soon as the patient is willing to begin. No special emphasis is directed toward non-weight-lifting contraction until the end of eight or ten days; then, if the pain and effusion are well in hand, such movement is insisted upon several times each day.

The patient is kept in bed for from eight to ten days, depending upon the amount of discomfort. The drain is removed forty-eight hours after the operation, and the original type of dressing is reapplied. The stitches are removed usually on the seventh postoperative day. At that time a wide, bulky, snug bandage of semi-elastic material is applied, usually an A. C. E. bandage, or a stockinet bandage called a track bandage. On the tenth day the patient is allowed up in a chair, which is arranged so that he can sit without strain and with the knee flexed to a comfortable degree. On the following day he is given crutches and usually discharged to his home, bearing a little weight. He is instructed to increase the weight-bearing gradually as he feels able, to continue contraction of the quadriceps, and to begin voluntary flexion and extension of the knee while seated high enough to permit the leg to hang freely. The crutches are used for from one to two weeks, depending upon the patient's inclination and the rapidity of the recovery of mobility and of muscle strength. Local heat, massage, and diathermy form no part of the postoperative program, unless there is a complication, and passive movements are never used under any circumstances. The abolition of passive movements is founded on the opinion that they are of no benefit and may often be harmful by causing painful traumatic reactions which retard healing, irritate the soft tissues about the joint, and stimulate reflex spastic inhibitions to active motion.

TABLE I

ANALYSIS OF LESIONS

Type		No. of Cases
Hypertrophy of the infrapatellar fat pad		48
Hypertrophy of the alar ligaments		18
Derangement of the internal meniscus		62
Hypermobility	22	
Rupture	40	
Derangement of the external meniscus		16
Hypermobility	10	
Rupture	6	
Fracture of the cartilage		10
With displacement	8	
Without displacement	2	
Osteochondritis dissecans		12
Rupture of the anterior crucial ligament		4
Fibrosis of the synovia of the anterior crucial ligament		1
Complicating arthritis		7
Proliferative	3	
Degenerative	4	
Total		178

STATISTICAL ANALYSIS

The last consecutive 100 cases which were treated in accordance with this plan have been selected for statistical analysis, and the figures are presented as evidence substantiating the validity and useful applicability of the procedures. Results of essentially the same nature would be shown by similar studies of any other consecutive group of cases in the author's entire series of such arthrotomies; the last 100 were selected because of the accessibility of the records.

Table I shows the lesions which were found in this series of cases.

The practical impossibility of making a positive preoperative differentiation between so many different pathological conditions shows the advantage of an adequate incision so placed as to permit a thorough investigation of the entire joint. This is a strong argument in favor of the routine use of such an incision.

The postoperative complications are listed in Table II.

Naturally the fact that there were no deaths and no infections is a source of much satisfaction. This record is interpreted as a vindication of the program of the whole technique of preoperative preparation, operative procedures (including drainage), and the postoperative care. It is manifestly impossible to ascribe a major rôle to any one element in the composite whole of the factors involved. However, since drainage is the one procedure that is not generally employed by others, it would seem reasonable to suggest that drainage may be a very important factor. Certainly, the absence of any infections indicates quite clearly that drain-

TABLE II

POSTOPERATIVE COMPLICATIONS

	No. of Cases
Death	0
Infection	0
Excessive effusion	7
Adhesions and delayed return of motion	7
Recurrence of symptoms and signs of internal derangement	7
Reoperation	9
Manipulation to restore motion	4

age is not a contributing cause of infection. Of course, it may be that the number of cases of postoperative adhesions with delayed return of motion is larger than that encountered by other surgeons. If so, then perhaps drainage can be held responsible for the 7 per cent. with adhesions. At this risk, however, the author prefers to continue the use of drainage as long as the incidence of infection remains at such a low level.

Table III shows the end results of these operations.

TABLE III

POSTOPERATIVE COURSE AND END RESULTS

Recovery Period:	
Duration of bed treatment	
Average for 90 cases	9 days
Duration of use of crutches	
Average for 88 cases	16 days
Recovery of functional use	
Average for 88 cases	9½ weeks
End Results:	
Full recovery	95 cases
Slight remaining disability	5 cases

TABLE IV

ANALYSIS OF MENISCUS LESIONS

	No. of Lesions	Per Cent.
Internal meniscus	62	79.0
External meniscus	16	21.0
Total	78	100.0

The average duration of bed treatment (only nine days) is less than the author had supposed it to be. It has been customary to plan on ten days in bed, but the period has been shortened in accordance with the effusion and pain and with the patient's wishes. The short period of six-

teen days for the average use of crutches also is surprising. Both of these figures clearly show that the majority of the patients recovered rapidly. The fact that an average of nine and a half weeks was required to restore the knees to functional use was at first disappointing. However, this is not so discouraging in view of the fact that many of the patients were under workmen's compensation insurance, since it seldom is possible to return these patients to their work before the optimum improvement has occurred.

Table IV is presented to show the relative numbers of lesions of the internal and external menisci.

It is hoped that this demonstration that 21 per cent. of all meniscus damage occurred in the external meniscus may help reenforce the contention that the incision must be adequate. Many of the lesions in this series of cases would have been missed if it had not been such a simple matter to enlarge the antero-internal approach and in this way to gain easy access to the outer side of the joint.

In conclusion, the author wishes to emphasize the importance of all of the factors involved in the technique here outlined. It is not possible to show that any single factor is of paramount importance.

MORTALITY IN ORTHOPAEDIC SURGERY

Twenty-Three-Year Report of the New York Orthopaedic Dispensary and Hospital

BY FREDERICK L. LIEBOLT, M.D., NEW YORK, N. Y.

Fellow of The New York Orthopaedic Dispensary and Hospital

Much has been written concerning patients who have been restored to health by operative procedures, but little has been said of those whose death has been hastened or, in certain cases, actually caused by operative interference. Death is so much a part of life, and of medicine, that its inevitableness is perhaps sufficient reason for its lack of study.

In investigating the literature, it is worth while to note that mortality statistics are available upon practically every subject except orthopaedic surgery. There are vital statistics dealing with the death rate in various nations, in various diseases, in sailors and in taxpayers, in infants and in old people, in hot climates and in cold climates, in married males and in unmarried females, and in all branches of surgery except orthopaedic surgery. For that reason, there are no data available with which to enlarge this study of the mortality rate in orthopaedic surgery, or with which to make comparative ratios with other orthopaedic hospitals.

Many arguments have been advanced in explanation of the low death rate in orthopaedic surgery. The principal reasons seem to be two: First, acute emergencies are not as common in orthopaedic surgery as in general surgery; second, since operations are confined chiefly to the extremities, the peritoneal and thoracic cavities are not often entered. However, it should be mentioned that orthopaedic surgery is not without its dangerous operations, in spite of the few fatalities. Witness, for example, the pounding over the heart and lungs in fusing a long thoracic curvature of the spine, with the patient already embarrassed by a huge plaster jacket extending from head to knee. Consider the relationship of the abdominal cavity to lumbar ramisection of the sympathetic nervous system, and the relation of the pleural cavity to costovertebral transversectomy. Think of the close proximity of the spinal cord when the meninges are exposed in fusion of the spine, and, certainly, in laminectomy. Obviously, fusion of the cervical spine for fracture of the neck and removal of hemivertebrae are procedures not to be lightly considered.

Questions of importance to be answered are:

1. In what orthopaedic operations is surgical shock most common?

2. How frequently does embolism occur? With all the work that is performed upon the extremities and the bones, plus the almost constant use of the tourniquet over long periods of operating time, it seems that pulmonary, cerebral, and fat embolism should occur quite often.

3. Is postoperative pneumonia of frequent occurrence? Should it

TABLE I

PRIMARY CAUSES OF DEATH

Cause		No. of Cases
Tuberculosis of the joints		64
Tuberculosis of the spine	33	
Tuberculosis of the hip	20	
Tuberculosis of the knee	3	
Tuberculosis of the spine associated with tuberculosis of the hip	3	
Tuberculosis of the spine associated with tuberculosis of the knee	2	
Tuberculosis of the spine associated with tuberculosis of the sacro-iliac joint and of the shoulder	1	
Tuberculosis of the shoulder	1	
Tuberculosis of the sacro-iliac joint	1	
Poliomyelitis,* acute and chronic		15
Osteomyelitis,** acute and chronic		7
Lateral curvature of the spine		4
Gangrene of the foot		3
Genu valgum		2
Congenital dislocation of the hip		2
Tumor of the spine		2
Unstable fifth lumbar vertebra		2
Spastic paraplegia		2
Fracture		2
Fracture of the femur	1	
Fracture of the spine	1	
Acute suppurative arthritis of the foot		1
Congenital club-foot		1
Acute rheumatic fever		1
Osteitis fibrosa cystica		1
Hemivertebra of the spine		1
Total		110

* Acute, 8 cases; chronic, 7 cases.
** Acute, 5 cases; chronic, 2 cases.

not be expected, particularly in elderly people who suffer long, hard operations, such as those performed on the hip joint, and who are then wrapped in a wet plaster spica, extending from the chest to the toes, placed in bed with no warmth except for a few lights shining on the wet cast, and kept recumbent for many weeks?

The period selected for study was from January 1, 1912 to December 31, 1934. During these twenty-three years there were only 110 deaths out of 20,424 admissions to the hospital. Of the total number of patients admitted, all but 479 were operated upon; the total number of operations was 29,514. These numbers reduced to understandable figures mean that: one patient died out of every 181 operated upon (.0055 per cent.); one patient died out of every 185 admitted to the hospital (.0054 per cent.); and there was one fatality out of every 268 operations performed (.0037 per cent.).

The number of deaths per year ranged between two and six, with the

TABLE II

SECONDARY CAUSES OF DEATH

Cause	No. of Cases	
Meningitis		26
Tubercle bacillus	23	
Staphylococcus aureus	1	
Streptococcus viridans	1	
Streptococcus hemolyticus	1	
Surgical shock		16
Generalized tuberculosis and other conditions following localized tuberculosis		15
Miliary tuberculosis	1	
Amyloidosis	2	
Pulmonary tuberculosis	5	
Cachexia	7	
Septicaemia *		11
Bronchopneumonia **		5
Under anaesthesia		4
Embolism		5
Cerebral	2	
Pulmonary	3	
Myocarditis †		4
Hemorrhage ‡		4
Gangrene		3
Surgical infection		2
Accident at operation		2
Empyema		2
Diphtheria		2
Acidosis with persistent vomiting		2
Rupture of tuberculous abscess		2
Into the mediastinum	1	
Into the intestine	1	
Pneumothorax		1
Brain abscess		1
Typhoid fever		1
Measles		1
Syphilis		1
Total		110

* Following surgical infection in 4 cases.
** Following operation in 2 cases.
† Acute, 2 cases; chronic, 2 cases.
‡ Pulmonary in 2 cases.

exception of 1914, when there were no deaths, and 1917, 1918, and 1919, when the deaths per year numbered seven, ten, and eight, respectively. The ages of the patients varied from six months to seventy-three years.

The classification of mortality has been arranged as follows:

1. Primary cause of death or the disease which sent the patient into the hospital, such as tuberculosis of the hip.

2. Secondary cause of death or the contributory cause or causes, such as tuberculous meningitis.

Table I lists the primary causes of mortality.

In considering the secondary or contributing causes, the deaths were reclassified, as shown in Table II.

From this rather uninteresting mass of figures may be drawn much interesting discussion. For instance, why did fifteen deaths occur from poliomyelitis? The answer is that four were due to acute paralysis of the thoracic and abdominal musculature. Bulbar involvement caused another death. For reasons yet unexplained, two patients died of acidosis with persistent vomiting, without operation. Both were girls—one seven and the other two years of age—who, three and eighteen months earlier, had suffered acute poliomyelitis, resulting in weakness of the back, flail lower extremities, and poor abdominal musculature. One intraperitoneal hypodermoclysis was given to the first patient; 500 cubic centimeters of normal saline intraperitoneally, 400 cubic centimeters of glucose intravenously, and rectal taps were given to the other patient. Their conditions did not improve and both patients died on the fifth day. The remaining eight patients died following operative procedures.

This last fact brings up the question as to how long these eight patients were in the hospital for improvement of general condition, through rest and glucose feedings, prior to operation. In all, the length of time was over one week, and the average was eight days. This certainly appears to be sufficient time preoperatively. The causes of these deaths were surgical shock and septicaemia.

Surgical shock produced a total of sixteen deaths. These were analyzed from several angles: (1) type of operation; (2) length of anaesthesia; (3) number of vertebrae operated upon; (4) type of anaesthesia; and (5) period of the year.

1. *Type of operation:* In all except three cases, the operation was performed upon the spine. One of the three operations was a bilateral supracondylar osteotomy for genu valgum in a child of two years; another, the curettage and placing of bone chips in the femur for osteitis fibrosa cystica in a child of seven; and the third, fusion of the hip for tuberculosis in a child of three.

2. *Length of operation:* The time required ranged from forty to sixty-five minutes in the three cases in which the spine was not the site of operation. The time element was greater in the cases in which the spine was operated upon, ranging from one hour and twenty minutes to three hours and thirty-five minutes.

3. *Number of vertebrae operated upon:* The number of vertebrae fused in one stage ranged from five to twelve, and the number involved in laminectomy was four to seven. To-day rarely are more than four vertebrae fused at one stage; this, no doubt, is a great factor in the present decrease in mortality in such cases. It is worth noting, however, that in these cases the operative risk is greatly increased if paraplegia is present.

4. *Type of anaesthesia:* The anaesthesia used was straight ether for children and gas-ether or ethylene for adults. This conforms to normal standards.

5. *Period of the year:* The month of the year seemed to be very important in the causation of surgical shock. In this particular group fourteen of the sixteen deaths occurred in the warm months from May to October. The other two deaths took place during the cold months,—one in December and one in February.

Important in the production of mortality was septicaemia with eleven deaths,—four following surgical infection and seven following incision and drainage for acute or chronic osteomyelitis. The four fatal surgical infections were all in cases of fusion of the spine. Two patients with lateral curvature suffered streptococcus-hemolyticus septicaemia, and two patients with unstable fifth lumbar vertebrae suffered staphylococcus-aureus septicaemia.

Embolus following operation was responsible for five fatalities. Two were cerebral in type and three were pulmonary. One cerebral embolus occurred after exploration of a tuberculous hip, and the other followed extraction of an upper molar tooth in a patient who, eleven years previously, had undergone fusion of the knee for tuberculosis.

The three cases of pulmonary embolism followed, respectively, a subtalar arthrodesis, amputation of a leg, and fusion for lateral curvature. An embolus following the latter operation is difficult to understand, but, apparently, possible. The record stated that the patient's condition was satisfactory until suddenly she coughed up blood and promptly expired.

Acute hemorrhage progressing to death occurred four times. In one case hemorrhage followed incision and drainage of the ilium for osteomyelitis. Nine transfusions were given, three on the day of death. In another case acute hemorrhage appeared from a sinus of a tuberculous spine, upon which no operation had been performed. There were two fatal pulmonary hemorrhages: one occurred nine months after fusion of a tuberculous spine in a patient who was up and about; the other happened four days after exploration of the spine in a patient with carcinoma of the lungs and of the vertebrae.

It was very surprising to find only two deaths due to postoperative bronchopneumonia. One occurred nine days after thoracostomy for empyema in a patient with tuberculosis of the spine; the other took place eleven days after exploration of the spine for sarcoma in a patient aged sixty-two.

Four deaths occurred while the patients were under anaesthesia. Two of these patients were one and three years of age and both had straight ether. Another child was one and one-half years old and the type of anaesthesia was not recorded. The fourth patient was an adult who received ethylene. All died following induction and prior to operative shock. An autopsy on two of the children revealed no enlargement of the thymus gland.

Meningitis was the contributory cause of twenty-six deaths. Two of these were due to accidents associated with the operation. Streptococcus-viridans meningitis occurred twelve days after a spine fusion for tuber-

culosis, at which time pus escaped inadvertently. Staphylococcus-aureus meningitis was present two days after sequestrectomy of the spine had been performed, with accidental opening of the membranes, in a patient who, five months previously, had had a lumbosacral fusion that was followed by staphylococcus-aureus infection. The case of hemolytic-streptococcus meningitis followed a wound infection. Tuberculous meningitis was the cause of the other twenty-three fatalities, and these are to be discussed in a subsequent paper.

SUMMARY

A review of the mortality statistics in orthopaedic surgery at the New York Orthopaedic Dispensary and Hospital, over a period of twenty-three years, reveals the following significant facts:

1. Surgical shock was most common in extensive fusions of the spine for lateral curvature.

2. Embolism was of infrequent occurrence in spite of the almost constant use of the tourniquet over long periods of operating time.

3. Postoperative pneumonia was less frequent than would be expected.

4. Warm months were the most dangerous periods for operative procedures.

CONCLUSIONS

1. No more than five vertebrae should be fused at one stage because of the danger of surgical shock.

2. Second operations at the site of a previous operative infection should be avoided if possible.

SACRARTHROGENETIC TELALGIA

V. A Plan for Treatment

BY HORACE C. PITKIN, M.D., SAN FRANCISCO, CALIFORNIA

This article is the last of a series of five [8, 9]. It is based upon a statistical study of the treatment used in a series of 1,000 patients whose complaints originated in the lower back. It is limited in scope to the treatment of painful affections of the upper sacral joints and of the various supporting tissues that protect the structure and control the function of these joints. The purpose of this article is to present a comprehensive plan for the relief of sacrarthrogenetic pain, but the purpose of the entire series is to stimulate a greater interest in manipulative surgery of the spine.

Manipulative surgery is a therapeutic waif of lowly origin whose infancy and childhood have been shielded from the light of reason by a congenital veil of empiricism and quackery. Consequently, although manipulative surgery somehow has grown to stunted adolescence, the great body of the medical profession rightly has refused to accept a method of treatment that lacks a firm basis in scientific fact. However, our clinical experience indicates that such a basis is available in the recognition of the transitional patterns of scoliosis. In the fourth article of this series, it was demonstrated that all of the patterns of sacrarthrogenetic scoliosis may be reduced to the transitional patterns by gentle manipulation, but that the procedure is irreversible. Thus, although there is much to be learned in regard to the secondary patterns, the transitional patterns simultaneously provide a broad avenue of approach to a clearer conception of the mechanism of scoliosis and a reliable guide in the treatment of the temporarily scoliotic patient.

Any pathological process, except a neurotrophic disturbance, that involves a joint or the supporting mechanism of a joint, produces reflex muscle spasm and a temporary decrease in the mobility of that joint. The protective muscle response elicited by affections of the upper sacral joints is intense and prolonged, because of the fact that stability is paramount in sacrarthral structure and function. Moreover, sacrarthrogenetic muscle spasm results in wide-spread limitation of motion in primarily mobile joints, because the muscles which control the position of the sacrum go far afield for attachments to the spine and to the lower extremities. The steady spasm and the consequent postural defects combine with local pain, telalgia, disturbances of the sympathetic nervous system,* insomnia,

* Axillary hyperhidrosis almost always is present in acute cases. Circulatory changes and dermographia are fairly common. Gastro-intestinal and genito-urinary symptoms are seen infrequently. We have not found in the literature any explanation of these phenomena, but, since they appear, disappear, and reappear regularly and in concert with the local signs and symptoms of sacrarthrogenetic dysfunction, we feel no hesitation in classifying them as associated disturbances.

and fatigue to form a vicious circle which magnifies the disability. In order to focus attention upon the origin of this vicious circle, we have found it convenient to reclassify the pathological processes that commonly affect the upper sacral joints in terms of their ultimate effects upon sacrarthral stability. The following typical headings will serve to illustrate the method:

I. Decreased stability; increased mobility, or destruction:
   A. Physiological relaxation:
      1. Puberty;
      2. Menstruation;
      3. Pregnancy;
      4. Ankylosis of adjacent joint or joints.
   B. Postural strains:
      1. Normal spines;
      2. Congenital defects;
      3. Paralyses;
      4. Bone-deforming diseases.
   C. Traumata:
      1. Sprains of muscles, tendons, ligaments;
      2. Apophyseal subluxations;
      3. Sacro-iliac slips;
      4. Injuries to intervertebral discs;
      5. Fractures (and Kümmell's disease);
      6. Dislocations.
   D. Neurotrophic changes.
   E. Neoplasms.

II. Increased stability; decreased mobility, contractures, or ankylosis:
   A. Traumata:
      1. Sprains;
      2. Subluxations;
      3. Slips;
      4. Fractures;
      5. Hypertrophic arthritis.
   B. Toxic diseases:
      1. Myofascitis;
      2. Neuritis;
      3. Atrophic arthritis.
   C. Suppurative diseases of bones, joints, and supporting structures:
      1. Granulomatous;
      2. Chronic;
      3. Acute.
   D. Diseases of unknown etiology:
      1. Spondylitis deformans.
   E. Surgical arthrodesis.

III. Normal stability; normal mobility:
  A. Traumata:
    1. Sprains;
    2. Fractures.
  B. Surgical:
    1. Release;
    2. Support.

Within the primary divisions of this classification, each condition has been arranged in accordance with its severity, the least effective being placed first. In planning a rational therapeutic program, it should be noted that apophyseal subluxations and sacro-iliac slips may be present in conjunction with any of the affections listed in the first two primary groups of the classification. Therefore, the first therapeutic goal must be the restoration of the normal arthral alignment.* Before one can inaugurate such a plan of treatment, however, he must be able to differentiate between normal and abnormal arthral alignment. The measure of normal sacro-iliac alignment is the absence of a complete pattern of scoliosis, other than one of the two transitional patterns.** The measure of normal sacrolumbar (and other lumbar) vertebral alignment is the roentgenographic record, and particular attention should be directed to the filming and to the interpretation of the oblique views. The classification also tends to emphasize the fact that trauma may affect arthral stability in several ways. Furthermore, clinical experience shows that subluxations and slips are liable to recur, especially those that are found in the classification of decreased stability. Therefore, the second therapeutic goal must be the restoration of the normal arthral stability. When ligaments have been torn, the normal alignment must be maintained until the injured tissues are healed. In the event that cicatrization fails to restore the normal stability, varying degrees of support must be applied in accordance with the degree of the structural deficiency, and again the transitional patterns are valuable guides. Both patterns are produced by unequal, reflex muscle spasm, but the double transitional pattern characteristically

* For example: subluxations commonly are associated with fractures of the spine and, unless manipulative reduction of such fractures is practised, frequently remain unrecognized and unreduced during a long period of immobilization. The injured ligaments heal, and cicatricial contraction restores or increases the normal ligamentous tension in a position that perpetuates the arthral deformity. Finally, when immobilization is discontinued, intractable symptoms develop in relation to the joints that are not in alignment. Thus, one sees many fractured spines that are symptomless, despite gross bony deformity, and others that are the source of a major disability, although the roentgenographic examination gives evidence of perfect healing. From our studies of scoliosis in these contrasting types, we feel that the realignment of articulations is equally as important as the restoration of bony architecture in the determination of the final disability.

** This statement, of course, includes the provisions that there are no structural changes in the vertebral column, and that the lower extremities are equal in length. It is advisable to measure the length from the tip of the greater trochanter to the tip of the fibular malleolus, as a check on the usual measurement from the anterior-superior iliac spine to the tip of the tibial malleolus, since the latter measurement is affected by pelvic torsion. Increasing the inclination of one ilium increases the functional length of that extremity, but decreases the measured length, and *vice versa*.

is found when stability is decreased, and the single transitional pattern characteristically reflects normal or increased stability. Finally, certain pathological processes, notably the suppurative diseases and ankylosing spondylitis, tend to diminish the mobility of the affected joints. Any motion is liable to be painful in such cases, and the final therapeutic goal must be the complete obliteration of all motion.

The plan for treatment that we wish to present is based upon the foregoing principles of realignment, stabilization, and obliteration. Omitting all consideration of general treatment, the plan may be summarized as follows:

I. Realignment:
   A. Relaxation:
      1. Volition;
      2. Local heat (electric pad, lamps, diathermy);
      3. Traction;
      4. Analgesia (local, caudal, general);
      5. Anaesthesia (spinal, general).
   B. Manipulative reduction (fractures, subluxations, slips):
      1. Active;
      2. Passive.

II. Stabilization:
   A. Restoration of symmetrical ligamentous tension:
      1. Freedom from weight-bearing (rest in bed);
      2. Traction;
      3. Physical therapy (postural positions, local heat, manipulation);
      4. Surgical release (individual ligamentotomy, Heyman ligamentolysis, Ober fasciotomy).
   B. Restoration of symmetrical myotonus:
      1. Rest in bed;
      2. Traction;
      3. Physical therapy (postural exercises, massage, sinusoidal current);
      4. Outdoor exercises (walking, swimming, horseback riding).
   C. External support:
      1. Adhesive strapping;
      2. Belt, or girdle;
      3. Brace, or corset;
      4. Plaster (jacket, short spica).
   D. Internal support:
      1. Trans-sacral graft;
      2. Sacrolumbar grafts.

III. Obliteration:
  A. Spontaneous.
  B. Surgical:
    1. Sacro-iliac arthrodesis;
    2. Sacrolumbar facetectomy;
    3. Sacrolumbar arthrodesis.*

The principles of manipulative surgery in dislocations of the spine are well known. The first step is to unlock the articulations by slightly increasing the deformity, and the second step is to reduce the dislocation by traction, lateral bending, and rotation. The principle of manipulative surgery in stable spinal subluxations and stable sacro-iliac slips is identical with the first step in the reduction of the dislocations,—one gently increases the deformity until the articulations unlock. The actual reduction is accomplished by the normal repository forces of the ligaments and muscles that control the joint and usually is accompanied by a springlike snap as the articular surfaces are restored to normal apposition. Very little force is needed in these manipulations. In fact, gentleness is prerequisite to satisfactory results, since the use of force to increase the deformity and to overcome protective muscle spasm necessarily causes additional injury to traumatized ligaments. Furthermore, enthusiastic and poorly conceived manipulations of this type frequently produce subluxations in previously uninjured joints and occasionally cause fractures of articular processes.** For these reasons, the foregoing outline of treatment emphasizes relaxation as the first step in realignment. On the other hand, although unstable subluxations and unstable slips can be unlocked with ease, the depletion of the normal repository forces that allows an unstable position to persist also militates against a spontaneous reduction. Therefore, the principle of manipulative surgery in these cases is similar to the second step in the reduction of the dislocations,—instead of increasing the deformity, one gently opposes it until reduction takes place.

In approximately one-third (31.0 per cent.) of all the patients in this series who received treatment for sacrolumbar subluxations and sacro-iliac slips, reduction was accomplished by gentle manipulation, in the course of the physical examination, before the patient was aware of the examiner's purpose. In a slightly smaller number of cases (28.0 per cent.), the alleviation of spasm, by the local application of heat and by the cooperation of the patient in voluntary relaxation, allowed reduction without the use of undue force. In the remaining cases (41.0 per cent.), the slips were very painful, very stable, or very well protected by a powerful musculature, and other means of obtaining relaxation were employed. After an extensive trial of the various methods noted in the outline, we have come to the conclusion that the relaxation afforded by low

* The recent work of Haas has demonstrated that a definite distinction must be made between intervertebral bone grafts and intervertebral arthrodeses which customarily are grouped together as intervertebral fusions.

** We have seen the roentgenograms that were taken before and after the production of such a fracture.

TABLE I
A Brief Review of the Four Primary Types of Sacro-Iliac Slips

Primary Slip	Stability	Fixed Sacral Tilt	Fixed Iliac Angle
Increased angle	1. (Greatest)	Homolateral	Increased
Extension	2.	Contralateral	Increased
Decreased angle	3.	Contralateral	Decreased
Flexion	4. (Least)	Homolateral	Decreased

spinal anaesthesia (to the crests of the ilia) is ideal in this group. Complete relaxation is limited to the lower extremities and to the pelvis, where relaxation is needed, and the normal reflex protective mechanism is unaffected in the rest of the spine.

Many types of manipulation and many exercises have been devised for the cure of backache, but empiricism has governed the choice of the method with few exceptions. In beginning this study, we collected as many of these methods as we could obtain from all sources and divided them into three groups in accordance with their effect upon the fundamental motions of the spinal and pelvic joints, which are:

1. Flexion;
2. Extension;
3. Rotation and lateral bending:
   a. Spinal;
   b. Sacral, by pelvic torsion (antagonistic iliac motion).

TABLE II
A Summary of the Effects of the Procedure Illustrated in Figures 1 and 2 *

Manipulative Motion	Effect on Superior Joint		Effect on Inferior Joint	
	Sacral Tilt	Iliac Angle	Sacral Tilt	Iliac Angle
Flexion of superior hip and knee	Homolateral	Decreased		
Extension of inferior hip and knee			Contralateral	Increased
Rotation of pelvis toward inferior hip	Homolateral	Decreased	Contralateral	Increased
Rotation of spine toward superior hip				
Distraction of spine and superior ilium	Contralateral	Decreased	Homolateral	Increased

* The stable slips must be unlocked by increasing the fixed deformity, and the unstable slips are reduced most readily by the motion that corrects the deformity. The statistics presented in the fourth article of this series showed that any type of sacro-iliac slip is reduced in the inferior position more frequently than in the superior position, and the reason becomes obvious when Tables I and II are compared. Conversely, unilateral sacrolumbar subluxations almost invariably are reduced in the superior position in which the articular facets tend to be separated (unlocked) by the rotatory forces and in which the unstable downward subluxations tend to be replaced by the distracting force.

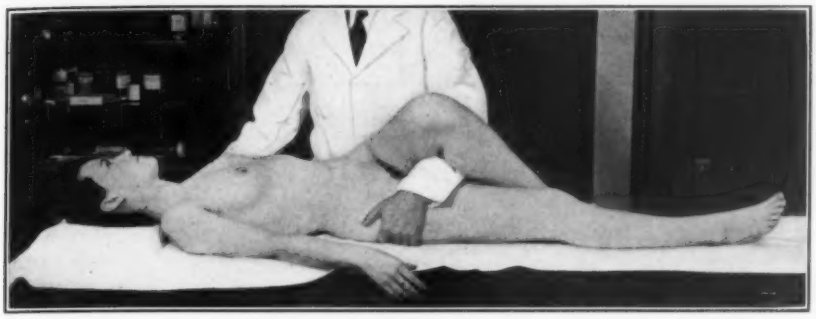


FIG. 1

The first step in the manipulation which the author has found to be most efficient in the reduction of sacro-iliac slips and sacrolumbar subluxations. One of the subject's hips has been flexed and the other has been extended. The operator is about to rotate the subject's pelvis toward the extended hip and simultaneously to draw the inferior hip backward beyond the center of the table (second step).

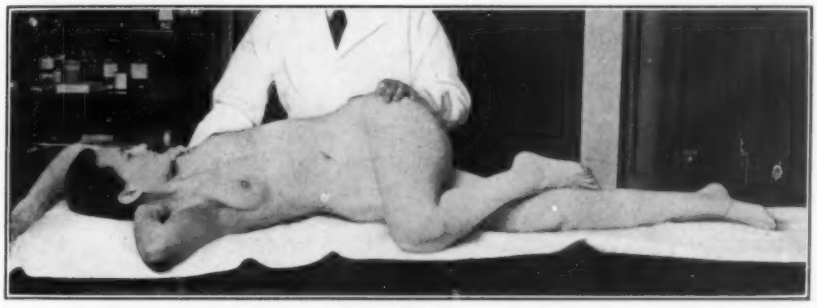


FIG. 2

The third step in the manipulation. (The second step has been completed, and the pelvis has been rotated until the normal limit of spinal rotation has been reached, so that the posterior shoulder is beginning to rise from the table. The fact that the sacrum is strongly tilted toward the superior hip readily can be deduced from the curve of the linea alba, which reflects the left lumbar scoliosis, and from the positions of the anterior superior iliac spines in relation to the iliac crests, which reflect the left pelvic torsion.) The operator presses gently downward and forward upon the superior ilium and upward and backward upon the posterior shoulder, thus adding to the rotatory force a distracting force that tends to reverse the sacral tilt.

At first, we manipulated each spine in all directions and recorded the manoeuver that produced a change in the pattern of the scoliosis. Gradually, we eliminated the methods that were inefficient, that caused pain, or that interfered with voluntary relaxation. Eventually, we discovered from our records that only one of the remaining manoeuvers regularly reduced every variety of sacrarthrogenetic scoliosis to a transitional curve or to an incomplete pattern. (See Figures 1 and 2.) In our experience, this procedure in its active form and supine, alternate, straight-leg lowering are the two most efficient methods of self-manipulation. The final step in this study was to reconstruct the mechanism of the successful method on the basis of the statistical probabilities that were presented in the fourth article of this series. (See Table II.) At the present time, we use almost exclusively (in accordance with

Figure 2 in the fourth article of this series[8]), the type of passive manipulation that is illustrated in Figures 1 and 2, and reserve other methods for the occasional case in which it fails.

Normal ligamentous tension is the first line of defense against luxation, partly because of the inherent strength of the ligamentous structure, but chiefly because of the direct reflex connection between the ligaments and the muscles which protect them. A contracted or irritated ligament sends warning of danger to the supporting muscles too early, and the result is limitation of motion. A ligament that has been stretched or torn sends warning too late to prevent repeated subluxations. In all cases that require a spinal anaesthetic for reduction, and in all cases that show a double transitional curve after reduction, we insist upon a period of rest in bed to provide for the restoration of symmetrical ligamentous tension. At the same time, adhesive traction (ten or fifteen pounds, depending upon the size and the muscular development of the patient) is applied to each lower extremity; this is not removed until the patient has been free from pain for at least forty-eight hours. The patient is not allowed out of bed (except for a brief reexamination) until he has been free from pain without traction for at least forty-eight hours, and until his spine shows an incomplete pattern of scoliosis or a single transitional curve. The use of physical therapy to relieve any contractures that remain after the reduction of ancient sacro-iliac slips needs no explanation. Persistent localized tenderness of a single ligament and characteristic telalgia that is relieved by the injection of procaine into the tender ligament are indications for individual ligamentotomy, provided that no sacrarthral instability is present. We have used this simple procedure in two cases with excellent results.* We also have used the Heyman ligamentolysis in five cases of persistent telalgia that followed surgical stabilization or arthrodesis, and the results were eminently satisfactory, but we have had no experience with the Ober fasciotomy.

If the ligaments are considered as the first line of defense against luxation, the muscles represent all of the other combat divisions in the army of support. Individual muscles that are kept in an almost constant state of reflex spasm for any considerable period of time simply "go stale", and, like a stale athlete, must be given an interval of complete rest and relaxation before training is resumed. The principles of muscle education and of postural training are too well known to need repetition. However, the fact that motoring, golf, and tennis are common causes of recurrent subluxations and slips has not been emphasized sufficiently, and the patient should be denied these activities as long as his spine shows a transitional curve.

* In one of these cases the telalgia persisted after the reduction of an ancient sacro-iliac slip, and the tenderness was localized to the long posterior sacro-iliac ligament at its insertion into the lower surface of the posterior-superior iliac spine. In the other case, the symptoms appeared gradually as late sequelae of an acute, traumatic, ischial bursitis, and were related to the sacrotuberous ligament. Both patients were relieved temporarily by the injection of procaine and were relieved completely by subcutaneous division of the offending ligament under local anaesthesia. The postoperative care was that of a sprain.

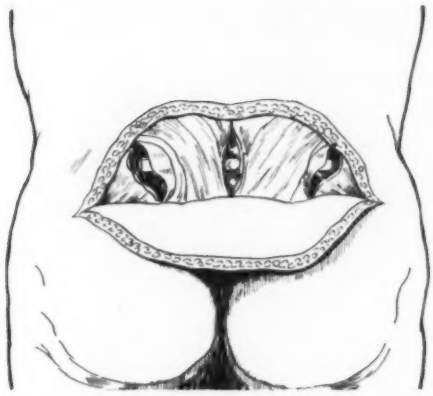


FIG. 3-A

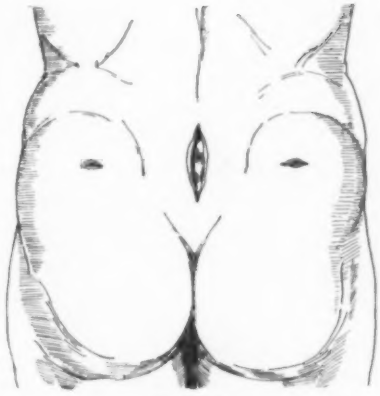


FIG. 3-B

A comparison of Verrall's incision (Fig. 3-A) with those advocated by the author (Fig. 3-B) for implanting the trans-sacral graft.

A sprained ligament normally is repaired in from three to six weeks, and rational treatment requires that the ligament be protected from additional injury until it is healed, especially if it is a part of a weight-bearing joint. Adhesive strapping still remains the standard form of external support in the average case of acute sprain, although the local use of procaine analgesia recently has been advocated for the relief of pain and reflex muscle spasm[4]. These generalities may be applied specifically to the upper sacral joints or to an ankle joint with equal logic, and we have found that the gradual disappearance of scoliosis reflects the progress of repair in the deeper joints just as accurately as does the disappearance of swelling and ecchymosis in the ankle. Consequently, the common practice of strapping backs for unreduced sacro-iliac slips appears to be almost as irrational as does the strapping of an unreduced dislocation in the ankle. On the other hand, the common practice of reducing sacro-iliac slips by manipulation without subsequently supporting the injured joints assures the manipulator of a brisk trade in recurrences

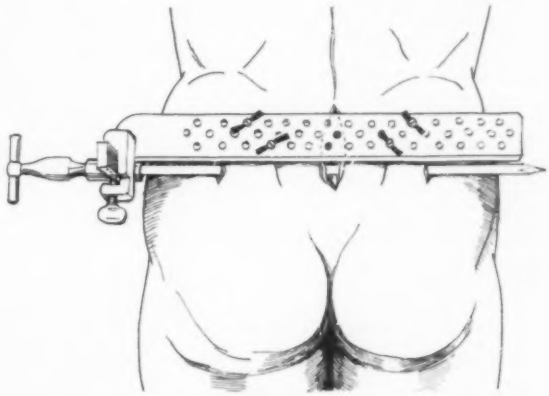


FIG. 4

A simplified technique for implanting trans-sacral grafts. The illustration shows a perforated plate which is subcutaneously fixed to the ilia by four screws and winged nuts and which holds an adjustable drill-guide, together with the special drill and removable drill-handle *in situ*. The butt of the drill is square and is recessed to hold the end of the graft. As the graft is driven through the prepared holes, it drives the drill ahead of it, so that alignment automatically is maintained.

FIG. 5-A

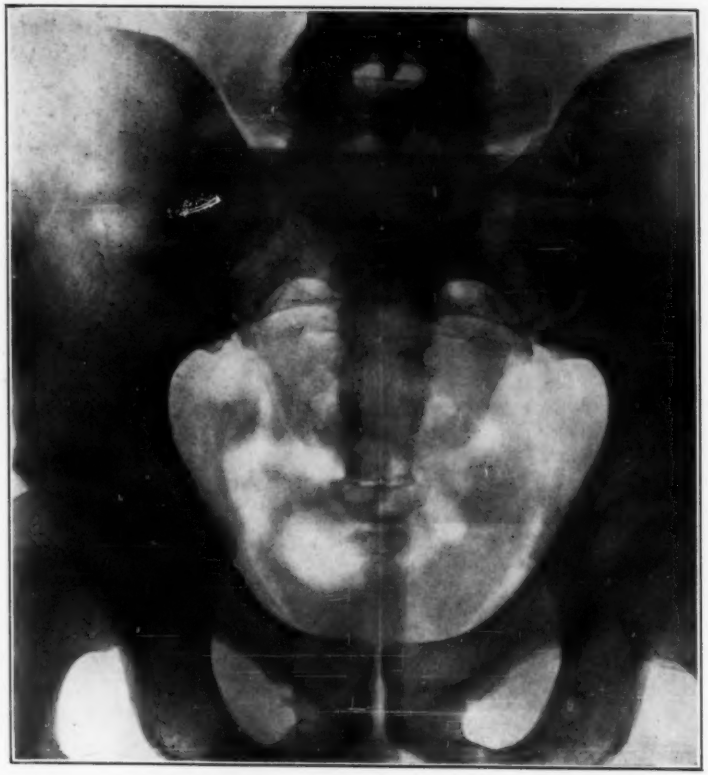


FIG. 5-B

Bilateral sacro-iliac relaxation, before (Fig. 5-A) and after (Fig. 5-B) implantation of a trans-sacral graft. Note the restoration of sacral alignment.

and results in a considerable proportion of permanently relaxed joints. Preferences in the matter of external support will not be listed here, since every physician has his favorite appliances which, in his hands, probably are more efficient than any that we might suggest. It is sufficient to note that one may gage the efficiency of a support by observing the manner in which it eliminates transitional scoliosis.

Verrall, in 1923, devised the trans-sacral bone graft and, three years later, reported its use in eight cases. Phelps and Lindsay slightly modified the technique and, in 1929, reported three cases. Ryerson, in 1932, condemned the operation on the basis of one case,* and Massart, in 1932, presented additional technical modifications in his report of two cases. Beginning with an operation in July 1930, we made extensive experimental technical changes in each of our first five cases, but the present procedure (Figs. 3-B and 4) has been used in twenty cases. For lack of space in this article, our experience with the operation must be condensed into the following statements:

FIG. 5-C

The lateral view shows the position of the graft at the junction of the first and second sacral segments, although the obliquity of the rays in the anteroposterior view casts the shadow of the graft upon the sacrolumbar junction. This graft subsequently became united to the overhanging spinous process of the fifth lumbar vertebra.

1. The trans-sacral graft is a square rod of cortical tibial bone that is extremely stable, because it is driven into round holes in the cancellous bone of both ilia and through the spinous process of the second sacral vertebra. (See Figures 5-B and 5-C.) In less than one year, the graft apparently is replaced by new bone which grows from the three points of bony contact and which, in the roentgenograms, has the soft density of

* Ryerson's reasons for condemning the operation are, in our opinion, its greatest recommendations in properly selected cases. He stated that at reoperation, one year after the implantation of the graft, perfect three-point union was found, but "definite torsion or twisting of the splint had developed", so that "both sacro-iliac joints were freely movable and the graft could be seen to rotate on its long axis in either direction". We have verified these phenomena in five cases, at reoperation, and have kept inclinometric records of the return of iliac mobility in the last twenty cases.

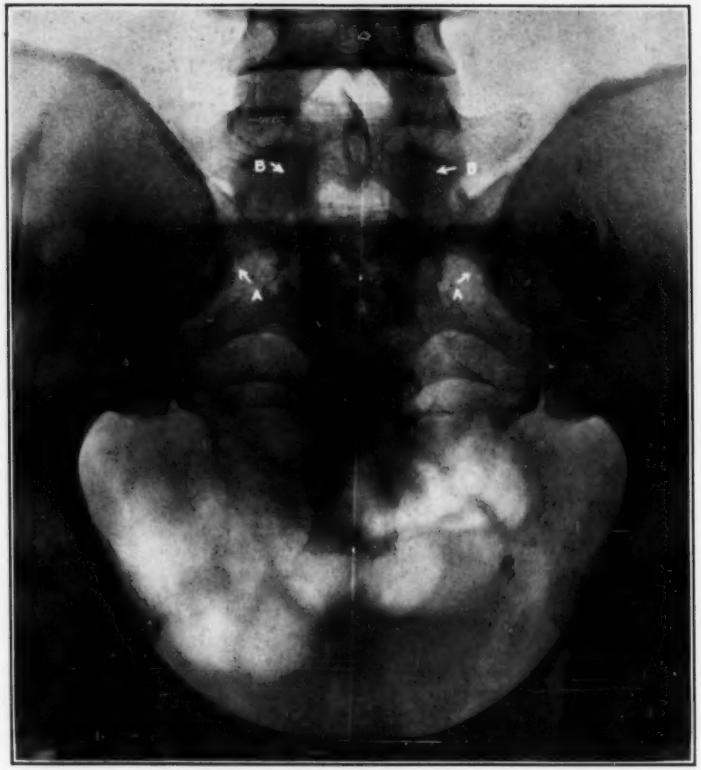


FIG. 6-A

FIG. 6-B

A trans-sacral graft eight months after implantation and immediately after the addition of sacrolumbar uprights (Fig. 6-A). The same case is shown eight months later (Fig. 6-B). The return of sacro-iliac mobility is reflected by the fact that the sacral alignment in the second view is imperfect. Note the formation of the thick, doubly arched bridge (at *A*,*A*) and the replacement of the grafts by cancellous bone (especially at *B*,*B*).

the parent bones. (See Figures 6-A and 6-B.) The resultant doubly arched bridge is larger than the original graft, and the comparative increase in the size of the two arches is in proportion to the degree of relaxation that exists in the corresponding sacro-iliac joints.

2. The operation is unique in bone surgery,—it is not an arthrodesis, and it does not supplant any other operation. The operation immediately restores sacro-iliac stability and supports the torn or relaxed ligaments with a rigid graft that gradually is replaced by flexible bone. As the density of the graft diminishes, torque appears, and the sacro-iliac joints, which at first are completely immobile, gradually regain a normal degree of motion, but remain perfectly stable.

3. The indications for the operation, therefore, are recurrent slips or sprains and uncontrollable sacro-iliac relaxations, especially those that are seen in patients who must return to heavy labor.

4. The contra-indications are a spina bifida of the second sacral segment and any disease or injury that causes a decrease in sacro-iliac mobility.

5. The advan-

FIG. 7-A

FIG. 7-B

Two lateral views that correspond with the anteroposterior views illustrated in Figs. 6-A and 6-B. Note that the trans-sacral graft and the upright grafts become welded together in a mass of cancellous bone that also fills in the space anterior to the uprights.

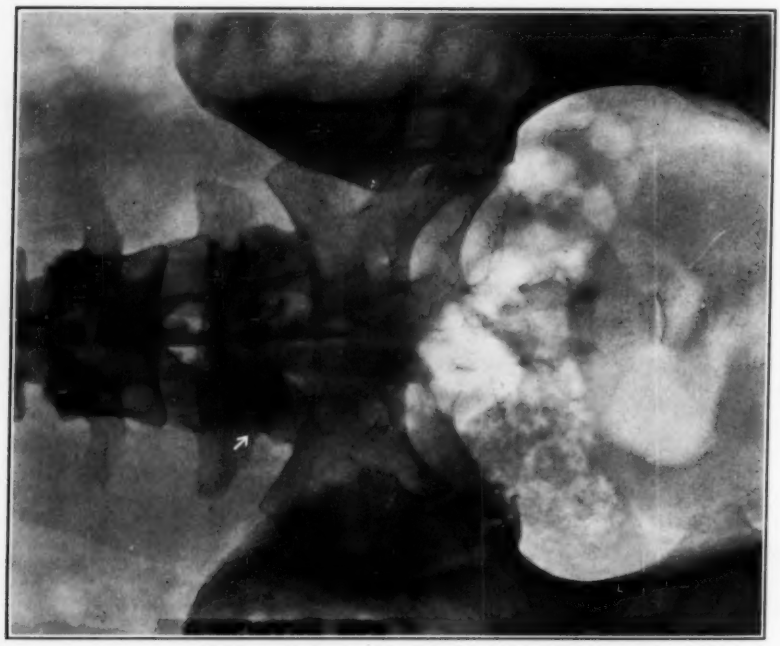


FIG. 8-B

FIG. 8-A

A right sacrolumbar subluxation before (Fig. 8-A) and after (Fig. 8-B) reduction and arthrodesis.

tages of the operation are a sound mechanical and physiological background, an operative speed that is comparable to that of unilateral arthrodesis, and the fact that the trans-sacral bridge forms an ideal foundation for sacrolumbar grafts.

6. The convalescence is remarkably short. No postoperative immobilization is used. The patients are allowed to be out of bed at their own inclination after the third postoperative day. They are permitted to leave the hospital at any time after the removal of the sutures on the tenth postoperative day, and they are allowed to return to work at any time after the eighth postoperative week (provided that they do not show a double transitional scoliosis).

7. The records show that some type of open operation was recommended to 9.5 per cent. of the patients in our series, that one or more operations were performed in 5 per cent., and that the trans-sacral graft was chosen for 2.5 per cent. In other words, 50 per cent. of all cases that came to open operation were considered to be suitable for trans-sacral grafts.

8. Sacrolumbar grafts were added to five (20 per cent.) of the twenty-five trans-sacral grafts. (See Figures 6-A, 6-B, 7-A, and 7-B.) The two upright grafts were driven beneath the trans-sacral graft until they were firmly wedged against the laminae of the fourth or fifth lumbar vertebra (the choice being dependent upon the degree of stability that was required). A posterior covering for the grafts usually was secured by splitting the spinous processes of the affected lumbar vertebrae and reflecting them bilaterally. We consider this to be the most satisfactory type of trisacral stabilization that we have seen. We do not use a cast in these cases, and one of our patients, who left the hospital on the tenth postoperative day and who consistently refused to wear a brace, almost convinced us that immobilization is unnecessary when short, strong grafts are used.

The indications for obliterative surgery are identical with the contraindications for supportive surgery. In this series, the Smith-Petersen sacro-iliac arthrodesis was applied to twenty-two joints in nineteen patients; one sacrolumbar facetectomy and five modified Hibbs sacrolumbar arthrodeses complete the obliterative group. Uniformly satisfactory results in this type of surgery cannot be expected unless all slips and subluxations are reduced before the arthrodesis is performed. (See Figures 8-A and 8-B)

SUMMARY

The author has classified each of the pathological processes that commonly affect the upper sacral joints in terms of its ultimate effect upon sacrarthral stability and has presented a comprehensive plan for the treatment of these conditions. Each item of the plan has been reviewed in the light of the author's experience in a series of 1,000 patients whose complaints originated in the lower back.

CONCLUSIONS

In the treatment of patients who complain of sacrarthrogenetic telalgia, the restoration of normal sacrarthral alignment by relaxation and by manipulation is the first therapeutic goal. This goal usually has been reached when the patient shows one of the two transitional patterns of sacrarthrogenetic scoliosis. Certain apophyseal subluxations provide exceptions to this rule and must be excluded by roentgenographic study, especially of the oblique views.

The restoration of normal sacrarthral stability, by methods designed to promote symmetrical tension in the ligaments and in the muscles that support the upper sacral joints and by the application of external or internal support, is the second therapeutic goal. When this goal has been reached, the patient usually shows an incomplete pattern of scoliosis.

Whenever alignment and stability are normal, but a condition of decreased mobility is present that is incompatible with painless function, obliteration of the offending joint by arthrodesis is the final therapeutic goal.

REFERENCES

1. Haas, S. L.: Study of Fusion of the Spine with Particular Reference to Articular Facets. J. Bone and Joint Surg., XVIII, 717, July 1936.
2. Heyman, C. H.: Thoughts on the Relief of Sciatic Pain. J. Bone and Joint Surg., XVI, 889, Oct. 1934.
3. Hibbs, R. A.: An Operation for Pott's Disease of the Spine. J. Am. Med. Assn., LIX, 433, 1912.
4. Leriche, René, and Arnulf, G.: Treatment of Sprains by Interligamentary Injection of Novocaine. Am. J. Surg., XXXII, 45, 1936.
5. Massart, Raphael: Verrouillage iléo-sacro-iliaque par greffon tibial comme traitement de la sacro-coxalgie. Bull. et Mém. Soc. Nat. de Chir., LVIII, 862, 1932.
6. Ober, F. R.: Back Strain and Sciatica. J. Am. Med. Assn., CIV, 1580, 1935.
   The Rôle of the Iliotibial Band and Fascia Lata as a Factor in the Causation of Low-Back Disabilities and Sciatica. J. Bone and Joint Surg., XVIII, 105, Jan. 1936.
7. Phelps, W. M., and Lindsay, M. K.: Extra-Articular Fixation of Sacro-Iliac Joint. Surg. Gynec. Obstet., XLIX, 555, 1929.
8. Pitkin, H. C.: Sacrarthrogenetic Telalgia. IV. Differential Diagnosis in Sacrarthrogenetic Scoliosis. J. Bone and Joint Surg., XVIII, 1008, Oct. 1936.
9. Pitkin, H. C., and Pheasant, H. C.: Sacrarthrogenetic Telalgia. I. A Study of Referred Pain. J. Bone and Joint Surg., XVIII, 111, Jan. 1936.
   Sacrarthrogenetic Telalgia. II. A Study of Sacral Mobility. J. Bone and Joint Surg., XVIII, 365, Apr. 1936.
   Sacrarthrogenetic Telalgia. III. A Study of Alternating Scoliosis. J. Bone and Joint Surg., XVIII, 706, July 1936.
10. Ryerson, E. W.: Surgical Treatment of Low Back Disabilities. J. Bone and Joint Surg., XIV, 154, Jan. 1932.
11. Smith-Petersen, M. N.: Arthrodesis of the Sacroiliac Joint. A New Method of Approach. J. Orthop. Surg., III, 400, Aug. 1921.
12. Verrall, P. J.: A Bone Graft for Sacro-Iliac Fixation. J. Bone and Joint Surg., VIII, 491, July 1926.

THE USE OF MECHANICAL SUPPORT IN THE TREATMENT OF FOOT AFFECTIONS

BY ERNST FISCHER, M.D., BUDAPEST, HUNGARY
Orthopaedic Surgeon, St. Stephan's Hospital, Budapest

There is scarcely any other phase of orthopaedic surgery about which there is more controversy than the conservative treatment of flat-foot and pes cavus. A great difference of opinion exists concerning the nature of the flat-foot deformity, as well as in regard to the therapy. In general, treatment by support is considered absolutely necessary, but some surgeons [1] oppose the use of any support. The author, himself, has experienced the inadequacy of supports fashioned in the usual shapes. The size, shape, and pliability of the supports, as well as the method of taking the impression, differ in every orthopaedic institution. New types of support are continually being offered, which, however, usually lack anatomical and mechanical perfection.

The purpose of this paper is to state the general opinion of the nature of flat-foot that is held by the majority of orthopaedic surgeons on the Continent, and to describe the support which the author has employed for many years and which differs in many respects from those in general use.

ETIOLOGY OF FLAT-FOOT

Under normal conditions, the foot is held in its plantigrade position by the supinators. Inactivity—the wearing of shoes, the habitual turning outward of the foot, etc.—results in weakness of these supinators, which, due to the weight of the body, causes the heel to sag into pronation. The surface of the calcaneum becomes inclined, and the talus, resting on the calcaneum, is forced by the weight of the body in a plantar, medial, forward direction from its own inclined plane. The caput tali pushes the os naviculare forward, thus resulting in an abnormal mobility (hypermobility) of the tarsus.

The normal architecture of the foot is maintained by the sole muscles. The tarsal and metatarsal bones are relatively more or less mobile when the foot is at rest. Under weight-bearing, they become fixed by the natural contraction of the sole muscles, and, therefore, weakness of these muscles results in laxity of the tarsus. This, in turn, causes the forefoot to bend upward,—an intratarsal reflection which occurs each time the sole is placed on the ground.

The forefoot cannot participate in the pronation of the heel; the counterpressure of the ground forces the first metatarsal upward into a position of relative supination at each step. This pathological torsion causes flattening of the transverse and longitudinal arches, because the head of the first metatarsal is at the same time the frontal and the medial pillar of both arches. The pathological supination of the forefoot is

synchronous with the pathological pronation of the heel, which causes a further laxity of the ligaments of the tarsal joints.

The counterpressure of the ground also results in a bending of the forefoot sideward and outward, producing a position of abduction. This is increased partly by the greater lowering of the higher medial longitudinal arch in comparison with the lateral arch, and partly by the habitual abducted position of the foot, which produces an enlargement on the inner side.

The lowering of the arches of the foot, which previously has been considered the chief factor in flat-foot deformity, is, on the other hand, the result of the pronation of the heel, of the laxity of the tarsus, and of the reflection of the anterior portion of the foot.

In the initial stage, flat-foot is always accompanied by hypermobility of the tarsus, which may exist for several years. Sooner or later, however, there develops a reflex contraction of the muscles (the peronei, the tibialis anterior, and the extensor digitorum longus), accompanied by a retraction of the ligaments,—the spastic flat-foot. The deformation of the bones, which may have commenced during the phase of hypermobility, gradually increases and finally the various deformities of the foot develop.

TREATMENT OF FLAT-FOOT

Since the acquired flat-foot is caused by the weakness of the muscles, the prevention and treatment of this condition must consist in the strengthening of the muscles, particularly of the supinators and of the short muscles of the sole. To accomplish this, gymnastics are necessary, but they can never be done daily over a sufficient length of time. Hence one is compelled to make use of the arch support.

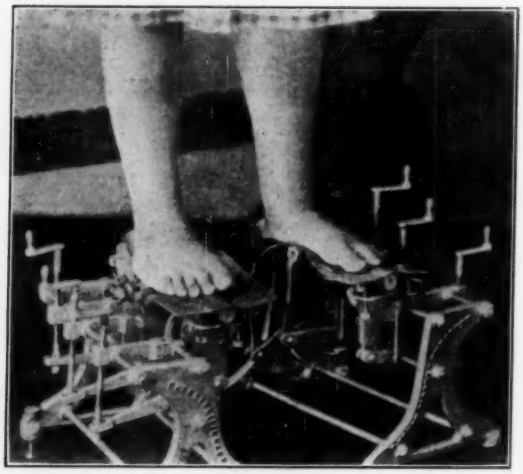


FIG. 1

Modeling apparatus. (*Courtesy of Zeitschrift für orthopädische Chirurgie.*[5])

In view of the factors which are chiefly responsible for flat-foot, the support should have the following objectives:

1. Correction of the pronation of the heel, which originates at the standing phase;

2. Prevention or correction of the reflection of the forefoot in standing and in walking *;

* If marked deformity is present, the support should force the heel into a varus position and the forefoot into plantarflexion and normal torsion.

3. Provision of a rigid support in case of mobile flat-foot.*

In the case of contracted spastic flat-foot, the redressement of which for certain reasons is not indicated, the author recommends tilting shoe heels in addition to the support. The outer side is made of soft rubber, so that the heel tilts toward that side at each step, and the contracted peronei and the retracted ligaments gradually stretch out (the principle of the Thomas heel).

Only in severe and neglected cases does the author resort to redressement under anaesthesia, consisting of plastic stretching of the tendons of the peronei and manual loosening of the tarsal joints without undue force. Then, with the heel in supination and the forefoot in pronation, a plaster bandage is applied, which is worn for four weeks. After the bandage is removed, the patient is not permitted to take even one step without support.

FIG. 2

Planter view of the bones of the foot, showing the transition from the heel part to the forefoot. The dotted lines represent the outlines of the type of support used by the author.

PREPARATION OF MODEL

The plaster impression should be made during normal weight-bearing, and correction should be applied with the patient standing. This cannot be done manually; therefore, a modeling apparatus (Fig. 1) is necessary. This apparatus has been described by the author in previous articles.[4, 5, 6]

The tread-plate of this apparatus consists of three parts: (1) the heel, which may be lifted, lowered, and tilted in order to attain the proper correction of the pronation of the heel; (2) the middle portion, which reconstructs the longitudinal arch; and (3) the anterior portion, which aids in the restoration of the normal torsion of the forefoot and of the vault of the anterior transverse arch.

The patient stands on the modeling apparatus and the necessary correction of the deformity is made. During this process the patient is able to feel and can describe his sensations. After the correction has been accomplished, the patient sits down and on his feet is placed a plaster slab, which reaches to the malleoli and which covers the heel, the sole, the two sides of the foot, and the extended toes. A strip along the dorsal portion of the foot is left uncovered, and the slab is then secured to the foot by a circular bandage of gauze. The patient then steps on the tread-plate, previously set, and awaits the hardening of the plaster. After the removal of the gauze bandage, the negative plaster model may be taken from the foot without being slit. After this negative has been filled with plaster, it then becomes the positive model of the impression from which the size and shape of the support are determined.

* In the case of contraction, the support should have a limited elasticity.

THE FOOT SUPPORT

Three parts of the support should be considered: the heel, the middle, and the forefoot. (See Figure 2.)

Form

The heel part of the support extends from the posterior end of the foot to Chopart's joint. It is more or less trough-shaped, and its purpose is to correct the pronation of the heel. The antivalgus prop, an elevation under the inner side of the heel, is, therefore, an important part of the support. This prop should be applied so that it rests on the solid part of the shoe heel. If the shoe heel is not of the correct height and width *, the best support will not eliminate the valgus deformity.

In order to prevent the foot from sliding off of the oblique plane of the support, in case of severe valgus deformity with hypermobility, a higher outer edge may be applied on the heel part. In order to correct perfectly the tendency to valgus, all of the bones of the tarsus must be sufficiently propped up.

FIG. 3

Model showing outlines of the gradually lengthened supports.

A B

FIG. 4

A: The type of support employed by the author.
B: The too short type of support.

* For men and children, the heel should be two centimeters high and somewhat broadened at the bottom (not conically narrowed). For women, the height of the heel should be three and five-tenths centimeters and the width at the bottom should be at least four and five-tenths centimeters.

The middle portion of the support must be arched longitudinally as well as transversely, to correspond with the cross-vault of the foot. This part of the support is the broadest and contains the summit of the longitudinal arch, which is usually situated below the os naviculare and frequently under the first cuneiform.

The surface of the forefoot part of the support should also be arched both longitudinally and transversely. The convexity, however, should not be interrupted at any point, as is the case with the elevation supports [7, 9] which are so much in vogue. (See Figures 9 and 10.) This type of support has an elevation at its front end with a depression in back of it, which does not correspond to the anatomical structure of the foot and which induces a lowering in the region of the metatarsus. The elevation is usually situated too far back and does not correspond to the normal elevation of the lowered anterior transverse arch.

The height of the vault depends upon the necessity of elevating the anterior transverse arch. If there is lowering of the arch, the support should sustain directly the heads of the middle metatarsals, but there should be no elevation above the surface of the longitudinal vault. In the case of a fixed transverse arch, gradually lengthened supports should be applied. (See Figure 3.)

In case of lowering of the anterior transverse arch, the use of small spherical rubber sponges or pieces of felt beneath the depressed heads is often recommended. However, this procedure is of doubtful value,—as the depressed heads are lifted, their bases are lowered by the same amount and the bending upward (the reflection) of the forefoot is increased. Many surgeons apply on the sole a thick piece of leather, which is fastened transversely to the sole of the shoe in the region corresponding to the metatarsal bones. However, this does not correct the lowering of the central heads, and it increases the reflection in the loosened tarsus, which occurs during walking.

The width of the anterior part of the support may correspond to the width of the forefoot, in which case there must be provision for a convexity

FIG. 5

Showing the torsional and sustaining effect of the author's type of support.

FIG. 6

The author's support without leather covering. At the anterior end is a piece of leather which may be turned and interchanged. The steel rib, placed edgewise, serves as a reenforcement; the posterior end, as an antivalgus prop. To this prop are attached two prongs which pierce the heel of the shoe and prevent displacement of the support.

under the middle heads and a concavity under the first and fifth heads. Such a wide support would occupy too much space in the shoe. Therefore, in constructing his supports, the author retains only the middle convex portion, so that the first and fifth heads rest on the sole of the shoe. Thus, a long, narrow form (Fig. 4, *A*) is developed, which forces the forefoot at every step into plantarflexion and normal torsion, thus correcting the flat-foot deformity (Fig. 5).

The center of the anterior end of the support is usually located under the third head. Not infrequently, however, the lowering is the greatest at the second or at the fourth head. In such a case, the highest and foremost point of this portion of the support should be transferred so that it lies under the affected head. Two prongs are provided to secure the position of the support in the shoe. (See Figure 6.)

Length

It is generally recognized that the support must sustain the longitudinal arch. However, the fact is not so well known that the arch must be supported during the entire period that the foot is in contact with the ground. To accomplish this, the support must be sufficiently long (Fig. 7), and this is not true of most of the supports in general use. If the support is too short, it sustains only at the moment of standing. During the period of the contact of the foot with the ground, the counterpressure exerted by the ground loosens the tarsal joints and causes reflection of the forefoot at each step, even though the height of the support may be satisfactory. (See Figure 8.)

The author considers that an adequate arch support should extend at least to the heads of the second, third, and fourth metatarsal bones. Most arch supports extend only to the bases or to the middle of the metatarsal bones. (See Figure 4, *B*.) If there is lowering of the anterior transverse arch, or if, because of Köhler's disease, Deutschländer's disease, Morton's disease, etc., the raising of the head of the middle metatarsal is indicated, the support should be extended to this middle metatarsophalangeal joint. There is no danger of impeding the gait, since walking involves only the contour of the heads of the middle metatarsals.

The best proof that the support is of sufficient length and is in its proper position is obtained by a dorsoplantar roentgenogram taken with the foot in the shoe. (See Figure 10.)

The author attributes the majority of unsatisfactory results obtained by treatment with supports to the fact that the supports have been too short. Although a support is worn, at each step reflection of the forefoot and lowering of the longitudinal arch take place. Moreover, following the use of such a support, lowering of the transverse arch may develop, for the too short support allows a relatively greater dropping of the forefoot, due to the elevation of the middle part of the foot. From his experience the author does not hold tenable Saxl's opinion that the

FIG. 7

Showing the effect on the foot during walking of a sufficiently long support.

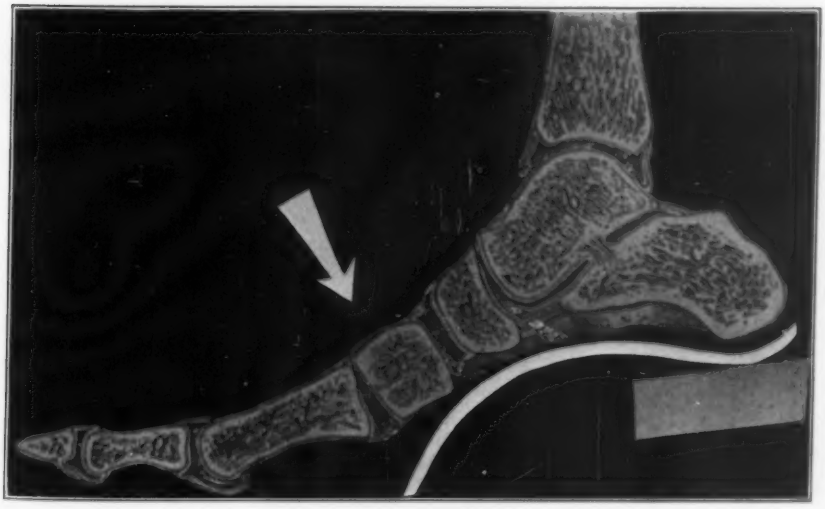


FIG. 8

Showing the effect on the foot during walking of a too short support.

FIG. 9

A: Model of foot, showing pes cavus with marked lowering of the anterior transverse arch and painful callosities.
B: Positive model, showing outlines of support of the proper length and form.
C: Elevation supports which are too short.

consequent lowering of the anterior transverse arch is caused by the too high arching of the support, for it is difficult to see how a patient could even tolerate a support so constructed.

At the junction of its middle and anterior parts, the support must sustain the bases of all five metatarsal bones. At the foremost part, it must support the diaphyses and the necks of the second, third, and fourth metatarsal bones. The diaphyses and necks of the first and fifth metatarsals should not be supported. According to circumstances, they should be forced to bend in a more or less plantar direction at each step. When the bases of all five metatarsal bones are supported, the plantarflexion of the first and fifth effects the reconstruction of the arches and of the normal torsion of the forefoot, since the heads of the first and fifth metatarsals are the forward pillars of the longitudinal and transverse arches.

Abduction of the forefoot may also be corrected by the use of this support. At each step the forefoot is forced to deviate slightly in a medial direction. Abduction of the forefoot cannot be corrected by the application of an outer edge at the diaphysis of the fifth metatarsal, for continuous pressure on this point cannot be borne. If the inner edge of the support is raised, pressure is exerted on the inner side of the protruded os naviculare. However desirable pressure may be at this point, the patient cannot endure it. Raising this edge has an additional drawback: the anterior margin prohibits medial deviation,—that is, the desired adduction of the forefoot.

Pliability

For many years the author has maintained that mobile flat-foot requires a rigid support [2, 3], for by this means only can the abnormal play of the lax tarsal joints be eliminated. In the case of contracted flat-foot, the problem to be dealt with is different. The contracted muscles and the atrophied ligaments should be treated gradually by elastic correction,—by a support with an elasticity limited according to the case.

A B

FIG. 10

A: Roentgenogram of foot with the author's support.
B: Roentgenogram of foot with a too short support.

In order to insure the rigidity or to impart the limited elasticity, a steel rib, placed edgewise and following the vault of the support, is riveted at each end to the inferior surface of the metal plate. (See Figure 6.) The mode of application of this rib determines the rigidity or elasticity of the support. If the rib lies tightly along the entire length of the metal plate, the support is rigid and is suitable for the treatment of mobile flat-foot. If between plate and rib there is a distance of from one to five millimeters (greatest in the middle and decreasing toward the ends), the support is elastic and may be used in treating rigid flat-foot. At each step the support has an undulating motion, which gradually mobilizes the contracted tarsal joints. After a few months, the distance between the plate and the rib may be decreased gradually until a rigid support can be used.

The steel rib serves other valuable purposes. Without it, a thick, heavy metal plate would be necessary. Placed edgewise, it reenforces the support. The posterior end of the rib serves as an antivalgus prop. To this prop are attached two prongs which pierce the heel of the shoe and thus prevent a displacement of the support in any direction. The anterior end of the rib is provided at its inferior surface with a round piece of leather which protects the sole of the shoe, and, by increasing the number of these pieces, it is possible to elevate gradually the anterior transverse arch and to increase the torsion of the forefoot.

PES CAVUS

In pes cavus the pressure of the body weight is distributed over a small surface of the heel and the forefoot, causing bursitis, periostitis, and

exostoses of the calcaneum and, with the overloaded and plantarflexed forefoot, a marked lowering of the anterior arch. These conditions, with the callosities which develop on the sole of the forefoot, render walking difficult and painful. Valgus deformity may be associated with pes cavus and occasionally the abnormally high arch of the foot becomes lax.

In the case of pes cavus, the aim of the support is to unweight the overloaded and sensitive parts and to correct gradually the lowering of the anterior transverse arch. This can be accomplished only by a support which has the proper length and form described. (See Figures 9 and 10.)

Operations which seek to correct the cavus deformity by merely lifting the head of the first metatarsal give a poor functional result, because the medial pillar of the anterior transverse arch is lifted from the ground and the lowering of the heads of the middle metatarsals is increased. Resection of the heads of the middle metatarsals destroys the architecture of the entire foot. The paring off of the calcaneal spur is also not indicated, for at the site of operation there remains a sensitive surface of bone and periosteum. If the heel portion of the support is trough-shaped, as described, pain in the calcaneum will cease. An opening in this part of the support is unnecessary.

In the case of a fixed anterior transverse arch with painful callosities, the length of the support should be gradually increased. (See Figure 3.)

SUMMARY

The conservative treatment of flat-foot and of pes cavus is based upon frequent adjustment of the support, gradual correction, and well-chosen gymnastics. Each component of the deformity must be taken care of during the modeling. The noteworthy feature in the construction of the support described is the employment of the dynamics of gait for correction. With this type of support pressure is distributed over the largest possible surface of the sole, but certain portions of the foot are unsupported in order to permit activity of the muscles of the sole,—particularly of the flexor hallucis longus and the peroneus longus. The type of the support always remains the same; it is merely adapted to the individual foot and to the factors which compose the deformity.

REFERENCES

1. Bankart, A. S. B.: The Treatment of Minor Maladies of the Foot. Lancet, I, 249, 1935.
2. Fischer, Ernst: Zur Frage der Elastizität der Plattfusseinlagen. Deutsche med. Wchnschr., LI, 1075, 1925.
3. Fischer, Ernst: Elastizität und Form der Plattfusseinlagen. Ztschr. f. orthop. Chir., XLV, 44, 1924.
4. Fischer, Ernst: Die Einlagenbehandlung des Knickplattfusses. Apparat zum Korrektionsmodellieren des Fusses im Belastungszustande. Ztschr. f. orthop. Chir., LII, 128, 1930.
5. Fischer, Ernst: Die Beachtung der einzelnen Komponenten des Knickplattfusses

bei der Korrektion mit Hilfe des Modellierapparates und bei der Einlagenanfertigung. Ztschr. f. orthop. Chir., LV, 364, 1931.

6. Fischer, Ernst: Zur Einlagenbehandlung des Plattfusses. Arch. f. Orthop. u. Unfall-Chir., XXXIII, 222, 1933.
7. Galland, W. I.: Semi-Flexible Brace, for Support of Longitudinal and Anterior Arches of Foot. Am. J. Surg., XVII, 442, 1932.
8. Saxl, Alfred: Beziehungen zwischen Insuffizienz des Längs- und Quergewölbes des Fusses. Ztschr. f. orthop. Chir., LX, 442, 1934.
9. Von Renesse, H.: Theorie und Bau der Plattfussstütze. Zentralbl. f. Chir., LXIII, 214, 1936.

A NEW TYPE OF KNEE HINGE AND CAST FOR THE CORRECTION OF KNEE-FLEXION DEFORMITIES

BY JAMES P. COLE, M.D., SC.D. (MED.), NEW YORK, N. Y.
Annie C. Kane Fellow, New York Orthopaedic Dispensary and Hospital

It is the purpose of this paper to describe a type of hinge for the correction of flexion deformities of the knee. The hinge is of simple construction; it is easily incorporated into a cast which is used to correct knee-flexion deformities; and, above all, it permits the correction with a minimum amount of trauma to the joint.

An important mechanical factor which should be considered is the fact that the true axis of motion of the knee is at a considerable distance proximal to the articular surface of the femoral condyles, and also the axis lies in a posterior position from the axis of the femoral shaft. This is exemplified in Figure 1. Multiple radii of curvature for the locus of the femoral condyles have been erected on the drawing. It can be seen that

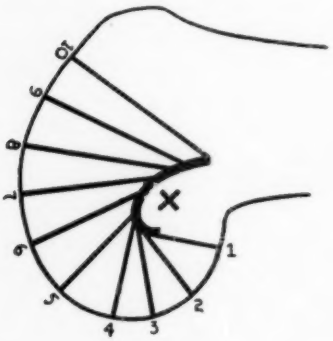


FIG. 1

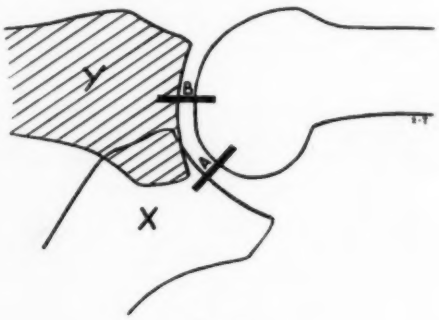


FIG. 2

these form an envelope (X), or the true axis of the knee joint approximates a cycloid, which is situated in a position posterior to the center of the axis of the femur and is also proximal to the articular surface of the condyle.

Another important mechanical factor must be taken into account when a knee-flexion deformity is to be corrected by the use of hinges in a cast. This factor is the constant change of the tibia in a vertical direction as extension is accomplished. The distance which the tibia must travel in an anteroposterior plane depends upon the degree of flexion at the start and, likewise, upon the vertical diameter of the femoral condyles. This principle is illustrated in Figure 2, a lateral view of a knee joint with the tibia and femoral condyles in flexion (X) and in extension (Y). In passing from the flexed position to full extension, the tibia travels in a vertical plane upon the femoral condyles from point A to point B. This

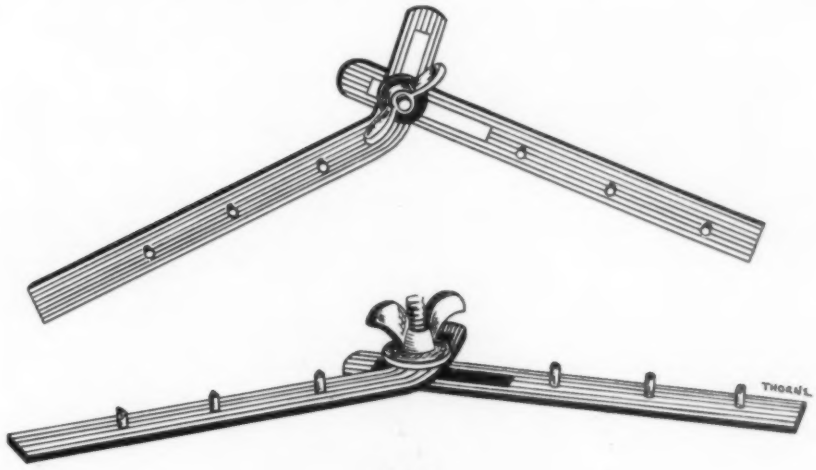


FIG. 3

distance varies with the vertical diameter of the femoral condyles and with the degree of flexion of the knee joint.

Figure 3 shows a type of hinge which is constructed to allow for the two important mechanical principles which have been described. The hinge, which is made of eleven-gage, thirty-per-cent. carbon steel, nine-sixteenths of an inch wide, may be found in almost any workshop. The two arms of the hinge are seven inches in length, and are joined together by an ordinary carriage bolt and a winged nut. The distal end (one and one-half inches) of the proximal arm is bent to an angle of from 45 to 60 degrees. This portion of the proximal arm is also slotted. The angulation and the slotting will permit the distal arm of the hinge to travel anteriorly upon the proximal arm, so that the tibia may also travel anteriorly upon the femoral condyles. This is not allowed when a single jointed hinge is used. The proximal end of the distal arm is also slotted for a distance of one and one-half inches. The slotting of this portion of the hinge permits the tibia to seek, without hindrance, a different radius of curvature upon the femoral condyles with each degree of extension of the knee joint. The two arms of the hinge are joined together through the slots by the carriage bolt and by the winged nut.

When a cast is used to correct a knee-flexion deformity, the two points which receive the greatest amount of pressure are at the lower anterior surface of the thigh and at the upper anterior surface of the lower leg. Even with an excess of padding, the edges of the cast are liable to dig into the leg at these points. Because of the discomfort to the patient, wedging is slow and at times pressure areas develop in these locations. Figure 4 shows the type of cast which is being used at the New York Orthopaedic Dispensary and Hospital to correct flexion deformities of the knee. In applying this cast the knee is padded anteriorly, and a few turns of plaster-bandage are wound about the knee. This plaster cuff

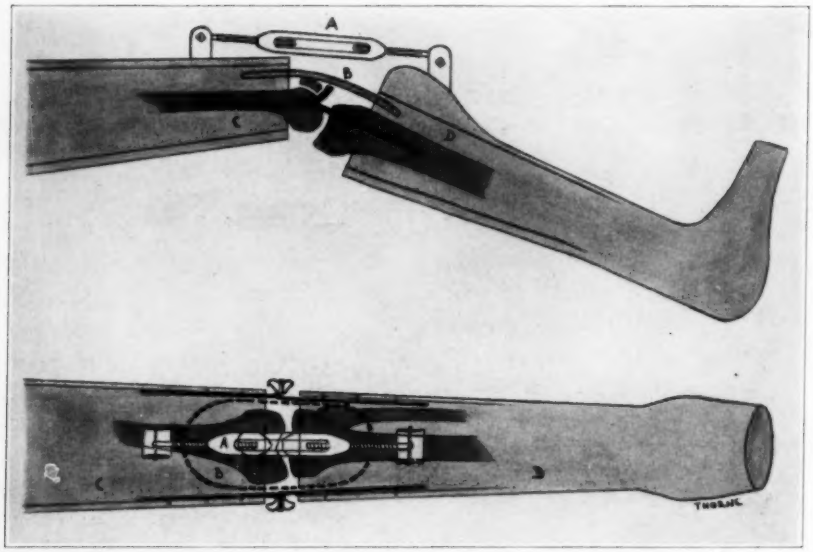


FIG. 4

Cast for correction of flexion deformities of the knee:
A: Turnbuckle *B:* Plaster cap
C: Thigh cast *D:* Lower-leg cast

is then removed by cutting along its posterior surface. From this cuff an anterior knee cap is cut out. This, with the padding, is applied to the knee anteriorly, after the edges of the cuff have been beveled on the surface which comes into contact with the knee. A long leg cast is now applied in two portions, one for the thigh and one for the lower leg and foot. Lateral hinges, which have been described, and either an anterior or a posterior turnbuckle are incorporated into these two portions of the casts. The anterior lower margin of the thigh cast and the anterior upper margin of the lower-leg cast are applied over the plaster knee cap, and are separated from it by a narrow strip of felt. The heel and upper thigh are padded as in all wedging casts.

As the turnbuckle is tightened and the flexion deformity of the knee is corrected, pressure is transmitted by the plaster cap along the entire surface of the knee, of the thigh, and of the lower leg, because the edges of the leg cast slide together upon the outer surface of the cap. As a result of this equal distribution of pressure, there is less pain from localization of pressure, and correction is gained in a shorter period of time.

After suitable correction has been obtained, the winged bolts of the lateral hinges may be tightened with a wrench, the turnbuckle may be removed, and the patient may be sent home. By the elimination of needless changing of casts, correction is constantly maintained.

FRACTURES AND DISLOCATIONS OF THE CERVICAL SPINE

PART I. FRACTURES *

BY SUMNER M. ROBERTS, M.D., BOSTON, MASSACHUSETTS

INTRODUCTION

To the layman the words "broken neck" are almost synonymous with "death". If perchance the injured person lives, he looks upon the event as a miracle. Unfortunately, many physicians take the same point of view. They look at the injured person, shake their heads, and confide to the family that there is nothing to do but to make him or her comfortable until the end comes. However, if the spinal cord has not been damaged (and it was irreparably damaged in only ten out of thirty-seven cases in this series), the end does not come, and the patient is doomed to live on, usually in discomfort and often with deformity. These sequelae are preventable in the majority of cases.

Knowledge of the fundamentals of fracture treatment is rapidly spreading throughout all communities. That these fundamentals are just as applicable to the cervical region as to other parts of the body is not general knowledge, however. It is the purpose of this paper to emphasize that a fracture of the cervical spine should be "set" just as a fracture elsewhere in the body is set, and that a dislocation of the neck should be reduced just as a dislocation elsewhere is reduced. These conclusions are based upon the treatment given and results obtained in thirty-seven cases of injury to the cervical spine.

With one notable exception, the literature on this subject has been confined almost entirely to the report of isolated cases. This again emphasizes the general feeling of wonderment among our profession, which leads to these reports of successful or surviving examples of treatment. The one exception is the work of Brookes, who has reported a series of over fifty cases. Langworthy reported a series of thirty cases, but his patients were not followed for a long enough time and a diagnosis was not carefully enough considered to make the series statistically valuable. This criticism (particularly as the author is no longer alive to answer it) is in no way meant to detract from the credit that is due him for recognizing and intelligently treating these injuries.

Cases of this sort are not frequently seen, and it takes a long time to accumulate any sizable series. It is hoped that these cases will further emphasize the feasibility of treating these injuries actively and not expectantly.

* Part II, dealing with dislocations, will be published in a subsequent issue of *The Journal*.

GENERAL CONSIDERATIONS *

Symptoms

The first and often the only symptom of a slight fracture of the cervical spine is stiffness of the neck. The patient often does nothing about it until it has persisted for some time. Physical examination usually shows tenderness over the spinous processes of the injured vertebrae. Tenderness laterally at the level of injury is commonly present also. If the injury is more severe, the pain and muscle spasm are more marked, and the patient is apprehensive about moving his head. There is frequently a definite deformity with the head bent forward and at the same time tilted to one side. The significance of this "torticollis" position will be discussed under dislocations. With still severer types of injury there is local hemorrhage and soft-tissue oedema. These may be sufficient to cause peripheral-nerve symptoms, due to compression of the nerve roots as they emerge from the cord, with referred pain and sensory and motor disturbances along the shoulders or down the arms. Occasionally there will be sufficient hemorrhage anterior to the vertebral bodies to cause pressure on the pharynx and difficulty in swallowing. Still more extensive injuries, particularly compression fractures, may so damage the spinal cord as to cause paralysis of any and sometimes all of the extremities and trunk.

Examination

A proper physical examination is essential in order to determine the extent and location of the injury. The most satisfactory position in which to examine the patient is the sitting one. This is not safe, however, if there is evidence of nerve or cord injury. The first thing that should be done, therefore, is to examine the patient neurologically. If there are positive signs pointing to nerve damage, the whole physical examination should be conducted with the patient lying down. This means that examination will be restricted to determining points of tenderness and to testing motion to a very slight degree, and that the ultimate diagnosis will depend upon the roentgenogram. Without evidence of neurological disturbance, the patient may be safely placed in a chair. The only precaution, but an important one, is never to allow any forward flexion of the cervical spine. The danger of permitting forward flexion of the head must be constantly kept in mind during the whole course of diagnosis and treatment.

Preliminary Care

It is not always possible to make an exact diagnosis as soon as the patient comes into the hospital. Roentgenograms must be taken and developed. Their interpretation is often difficult, and frequently it is necessary to take further roentgenograms. In the meantime the patient

* Many of these also apply to dislocations. Complications and operative treatment of these fractures will also be discussed in conjunction with dislocations.

must be cared for until a definite diagnosis can be made and permanent treatment decided upon. The neck is best protected from further injury and irritation by means of a head sling and traction. In order to prevent the traction from being applied in the direction of forward flexion, the patient must be absolutely flat. A Bradford frame with tightly stretched canvas not only keeps the patient flat, but also allows control of the entire spine. A pillow should be placed under the shoulders, thus allowing the head and neck to fall back into a position of hyperextension. (See Figure 1.) In the case of an adult, five or six pounds of traction is sufficient to steady the neck and to overcome muscle spasm.

Diagnosis

The first step in diagnosis is to evaluate the patient's history. There is always the story of trauma. The injury is usually one of moderate to severe violence, and, when a coherent account of the accident can be obtained, we find that the head and neck have been forcibly flexed forward. The history, therefore, tells us little that we do not know already,—namely, there has been an injury to the cervical region.

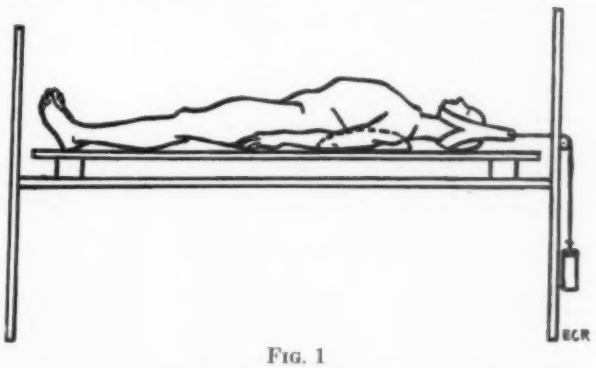


FIG. 1

Position of patient being treated with head traction. Note the pillow under the shoulders and the Bradford frame. Both prevent forward flexion of the neck.

The symptoms enable us to locate that injury more definitely, but they do not help us to differentiate between fracture and dislocation. Pain is an unreliable guide, and, although a fracture is liable to be more painful than a dislocation, yet simple soft-tissue injury or strain may simulate either of the more serious conditions. The presence of neurological disturbances, of course, is a great help in localizing the level of injury and to some extent its severity.

Physical examination is of greater importance than either history or symptoms. Posterior and lateral tenderness are as accurate in localizing the level of injury as are nerve or cord disturbances. Limitation of motions often gives valuable information as to whether we are dealing with a fracture or with a dislocation. In the presence of a fracture, all motions are guarded and painful. A dislocation, on the other hand, often allows certain motions to be unrestricted while others are markedly limited.

The roentgenogram is our most valuable asset and the one on which a final diagnosis is always made. If x-ray equipment is not immediately available, then the injury must be considered as serious until

roentgenograms prove it otherwise. It must be remembered that certain pathological conditions may exist in the cervical spine which may result in the production of a fracture by very slight trauma.

FIG. 2-A

Treatment

Wherever a fracture may occur in the human skeleton an attempt should be made to restore the injured bone to its normal shape and alignment. This is as true of the cervical region as of any other part of the body. Scar tissue and callus form here just as they do in other regions and the sooner reduction is attempted, the better is the chance of success. Except in rare instances reduction is by closed methods and,

FIG. 2-B

FIG. 2-C

Types of plaster jackets and head pieces. Note that the plaster comes well over the occiput and around the forehead and that its weight is carried on the pelvis, not on the shoulders.

FIG. 3-A

Leather collar made from plaster mold.

FIG. 3-B

Notice the high occiput and the brow band.

contrary to general belief, is no more dangerous than in other regions of the spine. In twenty-one cases, including both dislocations and fractures, the patients were put in traction and hyperextension for varying lengths of time without any untoward occurrence.

Whatever the type of injury, after reduction has been accomplished the question of fixation arises. In general, complete immobilization is necessary. This can be obtained only by means of a plaster cast. The ordinary Thomas collar which is so frequently applied in these cases is quite inadequate for primary fixation, although it is of value during the late months of treatment.

The plaster cast must extend from the top of the head to the pelvis. If it does not come up over the occiput, the patient can stretch his neck up and out of the chin piece and even turn it slightly from side to side. It is surprising how much ostrichlike motion the human neck is capable of, particularly in children. If the cast does not come low enough to grip the pelvic crests, the weight, which is considerable, will be borne on the shoulders and clavicles, and the patient will be extremely uncomfortable. (See Figures 2-A, 2-B, and 2-C.)

When the time comes to remove the plaster jacket and head piece, the best type of support is a molded leather collar (Figs. 3-A and 3-B). This gives better support than a Thomas collar and is not too sudden a change from the complete plaster immobilization. The transition from complete plaster fixation to entire freedom is further graduated by the use of a Thomas collar for a few weeks before all support is discarded. The importance of regular and gradually increasing active exercises during the periods when the leather and Thomas collars are worn cannot be stressed too strongly. When all support is finally removed, the muscles must have

regained sufficient strength to hold up the head without fatigue. The length of time that the various types of support are worn will be discussed under the various types of neck injuries.

FRACTURE OF THE SPINOUS PROCESS—4 CASES

(Cases 1, 2, 3, and 9)

Probably the simplest type of injury to the cervical spine is a fracture of the spinous process. It can be caused either by direct or by indirect violence, although the former is more common. In two of the four cases in this series (Cases 1 and 2), the patients received direct blows, and in the other two (Cases 3 and 9), the patients fell from considerable heights. Between them these four patients received ten fractures of the spinous processes, suggesting that these lesions are usually multiple. Treatment consists of traction in hyperextension until pain and muscle spasm have disappeared. This is followed by ambulatory fixation either in a molded leather collar or in a Thomas collar, depending on the severity of the injury. Since the elements of the supraspinal ligament which attach to the spinous processes are not powerful, a fixation period of from four to six weeks suffices. The only patient (Case 2) who had symptoms which persisted after healing was complete was one who had received a direct blow on the back of the neck with marked displacement of the fractured fragments of the second to the fifth processes inclusive. This man was not treated at the time of accident and four years later, at the time when this paper was written, he had intermittent symptoms which were relieved by applying head traction overnight at home. In one case (Case 3) non-union without symptoms resulted. It is conceivable that such a case might have persistent symptoms, and, if their severity warranted it, the author would not hesitate to remove the ununited fragment.

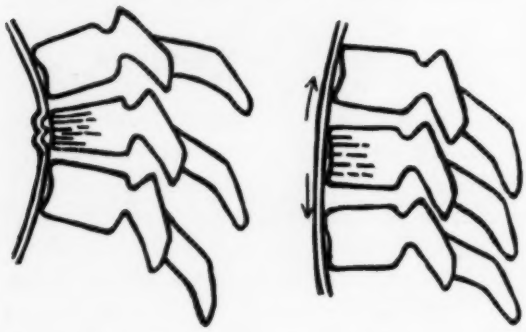


FIG. 4-A FIG. 4-B

Fig. 4-A: Compression fracture of the cervical vertebra. Note how the anterior longitudinal ligament has become slack where it is not attached to the vertebra.

Fig. 4-B: Treatment of the fracture by hyperextension. The anterior longitudinal ligament has been put on a stretch. Attached only at the margins of the vertebral body, it has exerted a distracting force on the compressed bone and has restored the normal contour of the vertebral body.

FRACTURE OF THE ODONTOID—5 CASES

(Cases 4, 5, 6, 33, and 35)

Fracture of the odontoid is a serious injury. When the odontoid is

fractured, and fracture usually takes place at the base, there is nothing to prevent dislocation of the atlas on the axis. This dislocation, in spite of the large neural canal, may seriously or even fatally compress the spinal cord. Furthermore, the odontoid is one of those regions where bony union takes place very slowly and where fibrous union alone is prone to occur. These facts make complete immobilization necessary.

Diagnosis of fracture of the odontoid is difficult. Because a fracture of the odontoid can occur without displacement and give rise to few symptoms, this region should always be x-rayed whenever there is evidence of injury to any part of the cervical spine.

The necessity of complete immobilization has been mentioned. This must be maintained for what at first may seem an inordinately long time. To remove support at an early date, however, is to court disaster, for a sudden movement or strain may shear off the weakly united odontoid and compress the cord. A complete plaster jacket and head piece applied in the manner described should be worn for a period of from two to three months. A molded leather collar should then be worn for a similar period, followed by a Thomas collar for another two months. Fixation during the later stages of treatment may be guided somewhat by roentgenographic examinations, but as a general and safe rule all fixation should not be removed before the end of six months.

At first glance this may seem like overtreatment. No injurious effects result, however, from this long immobilization, and normal motions are regained. On the other hand, inadequate fixation may result in non-union or in fibrous union. It is significant that the one case out of the five in this series which went untreated (Case 5) was the only one in which non-union occurred. All of the fractures of the odontoid were in adults and were the result of severe trauma. Three cases occurred without dislocation, and two were accompanied by a dislocation of the atlas on the axis. In order to allow complete bilateral dislocation to take place in this region, either the odontoid or the transverse ligament of the atlas must give way. Two out of five atlanto-axial dislocations were accompanied by fracture of the odontoid. Although one of these five patients had no odontoid, the relative strength of the ligament and the odontoid must be nearly the same, since each gave way in two instances. (Inquiry into cases treated elsewhere shows that the ligament is somewhat the stronger of the two structures.)

FRACTURE OF THE VERTEBRAL BODY—12 CASES WITH 17 FRACTURES

(Cases 7 to 18 Inclusive)

Under this heading only compression fractures will be considered. In this type the body of the vertebra is crushed between its neighbors, due to forcible flexion of the whole cervical spine. This tends to produce an anterior wedging of the vertebral body similar to that seen more frequently in the lower spine where there is less mobility than in the cervical region. It is not uncommon to see a small chip knocked off of the upper or

lower corner of a body in cases of forward dislocation of one vertebra on another, but in these cases treatment of the dislocation alone suffices.

Since the deformity of a compression fracture is greatest in the anterior portion of the body, hyperextension is necessary to restore normal alignment and contour. (See Figures 4-A and 4-B.) In order to be effective, this should be done as soon after injury as possible. If more than a week is allowed to elapse before treatment is begun, the same results must not be expected as if the patient were immediately cared for. How long a time must elapse before it is hopeless to expect improvement it is difficult to say, depending as it does upon the extent of injury and upon the patient's own power of repair. A slight improvement in bony contour was noted in one patient (Case 14) who had no treatment for three months following injury. Even if it seems impossible to expect any bony change, traction in hyperextension will help to stretch and to mobilize the soft structures, so that often a deformity that is marked in the roentgenogram may be invisible on physical inspection. To secure hyperextension, the author has used an inflatable rubber pad which is first placed under the patient in its deflated state. The upper end of the pad comes level with the base of the neck and, when air is pumped in, the patient's head gradually falls back into the hyperextended position. During this time no changes in the traction apparatus are necessary (Figs. 5-A, 5-B, and 5-C) and a pull of from five to eight pounds is sufficient.

FIG. 5-A

FIG. 5-B

FIG. 5-C

Showing the degree of gradual hyperextension obtainable by means of an inflatable rubber pillow.
Fig. 5-A: Pillow deflated.
Fig. 5-B: Pillow partially inflated.
Fig. 5-C: Pillow fully inflated.

When this gradual decompression of the fracture has been accomplished, the question of fixation arises. It is not safe to put on a plaster until the tissues at the site of fracture have reorganized sufficiently to prevent recurrence of the deformity. This time can best be determined by ro-

entgenographic examination. When callus formation first begins to show, which is usually in from six to eight weeks, it is safe to apply either a plaster cast or a molded leather support. The latter is preferable, as it is lighter and more comfortable, and can be removed for exercises. Two months later, the support may be removed for washing and shaving provided the patient performs these tasks in a recumbent or semirecumbent position. At these times recumbent exercises can be performed. No exercises should be done in the erect position until three months after injury, at which time the support may be removed daily for this purpose. When the molded leather collar is discarded, a Thomas collar is substituted for it, which is worn for two months. Fixation of some sort is, therefore, maintained over a period of six months. Attempts to dispense with support at an earlier date are liable to result in the recurrence of some or of all of the original deformity, and in addition there is the possibility of late complications. These are due largely to insufficient fixation and will be taken up in more detail later.

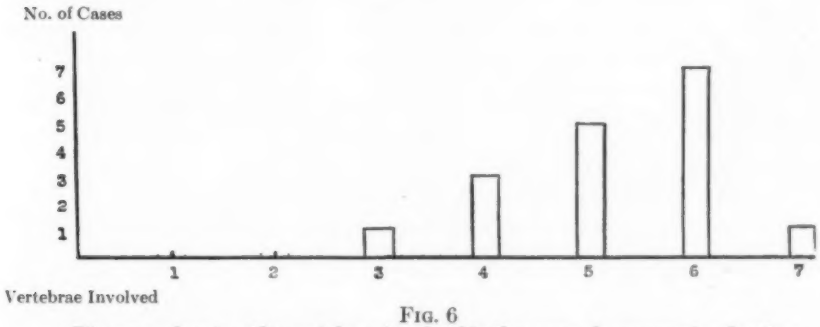


FIG. 6

Diagram showing the vertebrae involved in the cases of compression fracture. The greatest number of fractures occur at the apex of the curve when the neck is flexed.

Compression fracture is more likely to occur in the lower part of the cervical spine than in the upper. In no case in the author's series did the compression fracture involve the first or second vertebra and in only one case was the third vertebra involved. These fractures then became progressively frequent, reaching a peak at the sixth cervical vertebra (Fig. 6).

FRACTURES OF THE LAMINAE, OF THE PEDICLES, AND OF THE ARTICULAR FACETS

These fractures are usually complications of compression fractures of the body or of dislocations. The author believes that some such fracture almost always accompanies a complete dislocation in the lower portion of the cervical spine. Proof of this, however, is very difficult. Roentgenograms are hard to interpret, and a small fracture is easily overlooked. Even when a small fracture is seen, it is often impossible to say just what part of the vertebra is involved. Treatment of the concomitant more serious injury is the surgeon's first regard, and, fortunately, such treatment

is usually sufficient to take care of these lesser injuries also. Once in a while, however, such is not the case. For example, a patient (Case 20) came to the hospital and both physical and roentgenographic examinations showed what appeared to be typical of a complete bilateral dislocation of the fourth vertebra on the fifth. Manipulation was attempted with success only on one side, the other side failing to respond. Later, an operation was performed and the injured region was explored. On one side, the relationships were normal and, on the other, there was found a fracture of the lamina with forward displacement of the entire articulation without any dislocation. A fracture had been recognized roentgenographically before operation, but even reexamination of the roentgenograms after operation failed to show the exact pathology that had been found. Whenever proper treatment instigated early fails to obtain the desired result, the presence of one of these small fractures should be suspected.

CASE REPORTS*

CASE 1. R. B., male, aged forty-five.

December 1930: The patient was struck on the neck by a falling timber and sustained fractures of the spinous processes of the sixth and seventh cervical vertebrae. Sensory changes in the left arm resulted. Treatment consisted of immobilization in a plaster cast for one month, followed by a Thomas collar for one month.

August 1931: Examination showed complete healing without displacement. There were no sensory changes, but some neurasthenic symptoms (pain in the head, etc.) were present. The patient was not working.

November 1931: Figure 7 shows the condition eleven months after injury.

The poor economic result in this case cannot be blamed on the treatment.

CASE 2. C. D., male, twenty-six years of age.

1928: A blow on the neck by a swinging girder caused fracture of the spinous processes of the second, third, fourth, and fifth cervical vertebrae. No treatment was given at this time.

FIG. 7

Case 1. Fracture of the spinous processes of the sixth and seventh cervical vertebrae. Tracing from roentgenogram taken November 8, 1931, eleven months after injury.

FIG. 8-A

Case 2. March 8, 1932, five years after fracture of the spinous processes of the second, third, fourth, and fifth cervical vertebrae. Neck in hyperextension.

FIG. 8-B

Case 2. March 8, 1932. Neck held straight.

* Some of the cases referred to in the text will be summarized in Part II of this paper, where they more logically belong.

FIG. 9-A

Case 3. December 27, 1932. Fracture of the spinous process of the second cervical vertebra.

1929: The patient began to have pain along the back of the neck, which continued for three years. During this time he suffered a nervous breakdown. His case was studied at two hospitals, but no relief from symptoms was obtained.

1932: The patient entered the hospital and the symptoms were relieved by traction in bed. Figures 8-A and 8-B, tracings from roentgenograms taken on March 8, 1932, show the condition five years after injury.

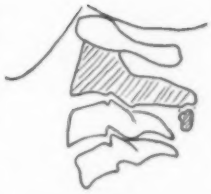


FIG. 9-B

Case 3. December 1, 1933. Eleven months after injury.

The delayed symptoms in this case were due to postural strain and to impinging processes.

CASE 3. J. W., male, seventy-nine years old.

December 1932: The patient fell down some stairs and fractured the spinous process of the second cervical vertebra (Fig. 9-A). Treatment consisted of a head brace for two months.

December 1933: Motions were normal, and there were no symptoms. There was no bony union (Fig. 9-B).

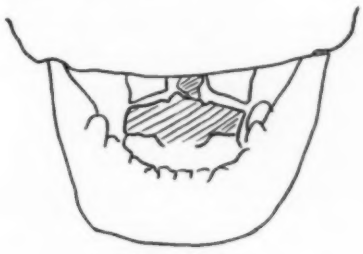


FIG. 10-A

Case 4. May 7, 1930. Fracture of the odontoid.

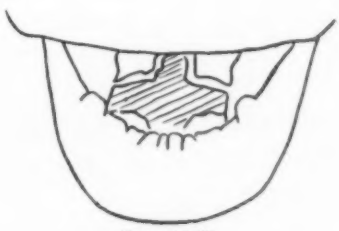


FIG. 10-B

Case 4. May 1, 1931. Firm union one year after injury.

If symptoms had persisted, the fragment would have been removed.

CASE 4. F. B., female, twenty-four years of age.

April 1930: The patient was in an automobile accident and sustained a fracture of the odontoid. (See Figure 10-A.) Treatment consisted of immobilization in plaster for three months, followed by a molded leather collar for three months.

May 1931: Roentgenographic examination showed firm union (Fig. 10-B).

November 1933: Motions were normal, and the patient was symptom-free.

Fracture of the odontoid is a serious injury and long fixation is necessary. However, in this series no ill effects resulted from the long period of fixation.

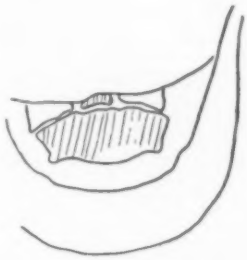


FIG. 11

Case 5. March 29, 1933. Four and one-half years after fracture of the odontoid.

CASE 5. C. C., female, aged fifty-five.

August 1928: The patient fell down a flight of stairs and fractured the odontoid and a hip. The injury to the odontoid was not discovered at first, as attention was focussed on the hip. The patient was given a Thomas collar, but

took it off every time that no one was looking. It was discarded entirely on discharge six weeks later.

March 1933: There were no symptoms, and motions were normal. A roentgenogram (Fig. 11) showed non-union.

In this case symptoms were obscure and the injury was nearly overlooked. Lack of fixation resulted in non-union.

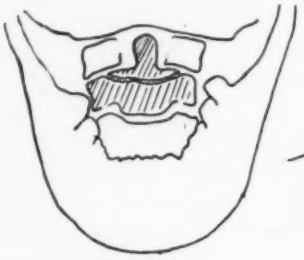


FIG. 12-A

FIG. 12-B

Case 6. October 9, 1931. Fracture of the odontoid.

CASE 6. P. F., male, fifty-five years of age.

October 1931: As the result of an automobile accident, the patient sustained a fracture of the odontoid (Figs. 12-A and 12-B). Traction was applied for one month, and a Thomas collar was worn for two months.

December 1932: Figure 12-C shows the condition thirteen months after the injury. Motion was limited and pain was present. The patient admitted that he had not done the exercises as directed.

FIG. 12-C

Case 6. Thirteen months after injury.

Fixation was inadequate and union took place because the fracture really involved the body of the vertebra to some extent.

CASE 7. F. C., male, thirty-two years old.

June 16, 1932: The patient dove into shallow water and sustained a fracture of the body of the sixth cervical vertebra, with slight dislocation (Fig. 13). There was complete cord compression at the level of the sixth cervical vertebra. Lumbar puncture gave bloody fluid, normal dynamics.

June 19, 1932: The patient died.

Operation or manipulation was not indicated because of normal dynamics at lumbar puncture.

FIG. 13

Case 7. June 18, 1932. Fracture of the body of the sixth cervical vertebra, with slight dislocation.

CASE 8. S. F., male, aged twenty-four years.

November 1933: Due to an automobile accident, the patient received a fracture of the body of the fourth cervical vertebra (Fig. 14-A). Extreme pain and spasm were present. The neurological examination was negative. After reduction (Fig. 14-B), traction was applied for two months. A leather collar was then worn for two months, followed by a Thomas collar for two months.

February 1935: A roentgenogram (Fig. 14-C) showed solid union. Motions were normal. The patient stated that his neck ached when he drove a truck; otherwise he was symptom-free.

Fractures without cord symptoms can be reduced just as can those in the lower regions of the spine.

CASE 9. C. H., male, thirty years of age.

April 1931: The patient fell forty feet, sustaining a fracture of the body of the fourth cervical vertebra and of the spinous processes of the third, fourth, and fifth cervical vertebrae (Fig. 15). There was a complete lesion of the cord at the fourth cervical vertebra. Lumbar puncture showed complete block. No treatment was attempted, and four days later the patient died.

This was a typical fatal case. The patient would probably have died

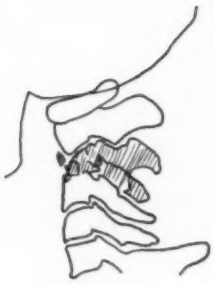


FIG. 14-A

Case 8. November 20, 1933. Fracture of the body of the fourth cervical vertebra.

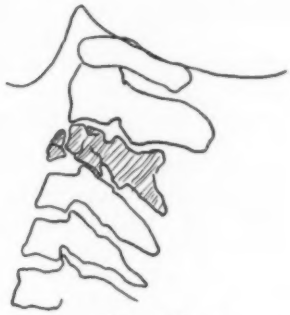


FIG. 14-B

Case 8. November 28, 1933. After reduction.

FIG. 14-C

Case 8. February 1, 1935. Solid union fifteen months after injury.

anyway, but, with complete cord block, traction should have been tried.

CASE 10. J. K., male, twenty-five years old.

1925: The patient dove in shallow water, resulting in fracture of the bodies of the fifth and sixth cervical vertebrae. There was complete paralysis at first. Lumbar puncture gave bloody fluid. Treatment (at another hospital) consisted of rest, with some improvement in the extremities during the following four months.

1932: The patient entered the hospital where roentgenographic examination (Fig. 16) revealed solid union. The arms were weak, the legs were spastic, and there were sensory changes. Lumbar puncture was negative.

FIG. 15

Case 9. April 29, 1931. Fracture of the body of the fourth cervical vertebra and of the spinous processes of the third, fourth, and fifth cervical vertebrae.

In this case, when the patient was seen by the author, it was too late for anything to be done.

CASE 11. T. S., male, aged sixty years.

December 1930: The patient fell off a truck and sustained a fracture of the body of the sixth cervical vertebra and dislocation of the fifth cervical vertebra on the sixth. There was weakness of the arms and of the legs, with reflex changes. Lumbar puncture was negative. Treatment consisted of traction for ten days and immobilization in plaster for one month.

March 1932: Roentgenographic examination (Fig. 17) revealed some loss of bony contour of the sixth cervical vertebra.

April 1932: There was no change in the extremities. Pain in the neck was continuous. Treatment consisted of a leather collar for six months with exercises and physiotherapy.

January 1933: The pain was intermittent and less severe. There was no change in the extremities.

FIG. 16

Case 10. March 9, 1932. Solid union seven years after fracture of the bodies of the fifth and sixth cervical vertebrae.

In this case the initial fixation was inadequate. The leather collar should have been applied at the time of the injury, not two years later.

FIG. 17

Case 11. March 11, 1932. Fifteen months after fracture of the body of the sixth cervical vertebra and dislocation of the fifth cervical vertebra on the sixth. There is some loss of bony contour of the sixth cervical vertebra.

FIG. 18-A

Case 12. November 14, 1933. Two months after fracture of the bodies of the sixth and seventh cervical vertebrae.

FIG. 19-A

Case 13. July 28, 1934. Fracture of the body of the sixth cervical vertebra.

CASE 12. J. L., male, sixty-four years of age.

September 1933: The patient fell twenty-six feet and fractured the bodies of the sixth and seventh cervical vertebrae. Paralysis of the arms and legs resulted. The patient was given rest at home, with some improvement.

November 1933: On admission to the hospital, the patient exhibited weakness and atrophy of the shoulders and arms. Lumbar puncture was negative. Figure 18-A shows the condition two months after injury. Treatment consisted of traction for two weeks, followed by a leather collar for four months.

April 1934: Figure 18-B shows the condition six months after injury.

November 1934: Roentgenographic examination revealed solid union. The arms were normal, and there were no symptoms. The patient was working on ladders and on roofs.

This is the type of case which is usually fatal.

CASE 13. G. L., male, aged sixteen years.

July 28, 1934: The patient dove in shallow water and fractured the body of the sixth cervical vertebra (Fig. 19-A). Complete compression of the cord resulted. Lumbar puncture gave pressure of 60 with no pulsation. Treatment consisted of hyperextension on a rubber pillow. (See Figure 19-B.)

August 5, 1934: Lumbar puncture gave pressure of 110 with pulsation. At this time the patient was put in traction for three months; then plaster shells were applied in order that the patient might be transferred to his home.

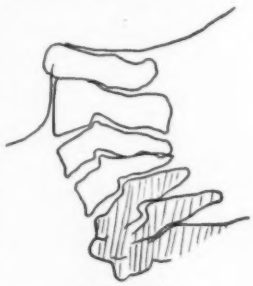


FIG. 18-B

Case 12. April 27, 1934. Six months after injury.

May 1935: There was improvement in the condition of the arms, but none in that of the legs.

Operation was not indicated, since traction reduced the fracture and relieved the complete cord block.

FIG. 19-B

Case 13. July 30, 1934. After traction in hyperextension on pillow.

CASE 14. M. M., male, fifteen years old.

July 1929: The patient dove in shallow water and sustained fractures of the bodies of the fourth and fifth cervical verte-

FIG. 20-A

Case 14. November 10, 1929. Three months after fracture of the bodies of the fourth and fifth cervical vertebrae.

brae. As a result the arms were paralyzed for ten days.

November 1929: The condition on admission to the hospital is shown in Figure 20-A. Neurological examination was negative. Treatment consisted of head traction with some improvement. (See Figure 20-B.) A leather collar was worn for six months.

November 1930: Motion was normal and there were no symptoms. Roentgenographic examination (Fig. 20-C) showed that the patient had lost a little of what had been gained.

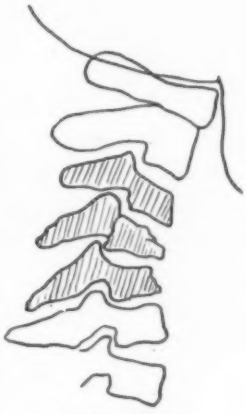


FIG. 20-B

Case 14. November 18, 1929. After head traction.

This case shows that even after three months some improvement is possible.

FIG. 20-C

Case 14. November 19, 1930. One year after treatment.

CASE 15*. H. R., male, forty-four years of age.

October 1930: The patient fell twenty-five feet and fractured the bodies of the fifth and sixth cervical vertebrae.

November 1930: The patient entered the hospital, and neurological examination was negative. Traction was applied for five weeks, followed by a leather collar for five months. During the latter period the patient was lost track of.

June 1931: There was involvement of the sixth and seventh nerve roots on the left with weakness and sensory changes. All motions were restricted and there was pain on motion.

FIG. 21

Case 16. August 14, 1934. Fracture of the body of the fifth cervical vertebra.

This case illustrates lack of after-care; also that nerve complications may arise several months after injury.

FIG. 22

Case 17. July 28, 1932. Fracture of the body of the third cervical vertebra.

CASE 16. C. R., female, aged twelve years.

August 1934: The patient fell out of a tree and sustained a fracture of the body of the fifth cervical vertebra (Fig. 21). There was slight sensory impairment of the fifth and sixth nerves. Traction was applied for two days, followed by a plaster collar for two months.

December 1934: Motion was normal and there were no symptoms. Neurological examination was negative; roentgenographic examination showed no change

FIG. 23

Case 18. November 20, 1933. Fracture of the body of the sixth cervical vertebra.

* Roentgenograms not available.

In this case the injury was slight and prolonged complete fixation was unnecessary.

CASE 17. S. S., female, aged eighty-six years.

July 1932: The patient fell down-stairs and fractured the body of the third cervical vertebra (Fig. 22). Lumbar puncture gave partial block. The patient died four hours after admission.

CASE 18. M. V., male, twenty-eight years of age.

November 1933: As the result of an automobile accident, the patient sustained a fracture of the body of the sixth cervical vertebra (Fig. 23), followed by complete paralysis. Lumbar puncture gave complete block. Treatment consisted of laminectomy. The cord was found to be hopelessly damaged, and the patient died two days later.

This is a typical fatal case.

REFERENCES

BROOKES, T. P.: Dislocation of the Cervical Spine. J. Missouri Med. Assn., XXVII, 579, 1930.

BROOKES, T. P., AND EWERHARDT, F. H.: On Reducing and Treating Cervical Dislocations. Arch. Phys. Therapy, XIII, 463, 1932.

LANGWORTHY, MITCHELL: Dislocations of the Cervical Vertebrae. Report of Thirty Cases. J. Am. Med. Assn., XCIV, 86, 1930.

MYOSITIS OSSIFICANS TRAUMATICA

BY RALPH F. BOWERS, M.D., NEW YORK, N. Y.

From the Surgical Department of the New York Hospital and Cornell Medical College

In treating myositis ossificans traumatica there are three types of cases which must be taken into consideration. These can be divided roughly as follows: (1) those cases in which no treatment is necessary; (2) those in which conservative treatment alone suffices; (3) those in which operative interference is necessary.

The first group, which is probably the most frequent type, is that in which, following minor injuries to the thigh and the buttocks (as in the case of athletes), small, calcified, symptomless areas are discovered in the muscle during examination for other conditions. These are probably the result of contusions or of subperiosteal hemorrhages, and in the organization that follows, by a means not clearly understood, calcification takes place. This type does not need treatment.

The second type presents more extensive calcified areas with definite symptoms and a mass, which is sometimes tender and which occasionally causes a certain amount of disability. Usually during the period of five to twelve months after the appearance of the mass, gradual absorption and ultimate disappearance without symptoms take place. It has been the author's good fortune to follow one of these cases, observing the softening of the mass and the beginning of its disappearance, and to make a pathological examination of the entire mass five months following the injury. An autopsy was obtained after the patient had succumbed to pulmonary tuberculosis.

The third type includes those cases in which the mass is usually located in the region of the joints, disabling the patient by ankylosing or limiting joint motion, and in which, after the proper period of observation, absorption does not occur. While cases of this type are not rare, they are infrequently seen.

The clinical and roentgenographic aspects of several hundred cases of myositis ossificans traumatica have been reported in the literature by Lewis, Finney, Noble, and Campbell. Etiologically the condition has been discussed by some of these same writers, and more notably by Painter and by Rohde. While several theories have been advanced and discussed, none completely accounts for the pathological physiology of the condition. Lewis and Campbell have well reviewed the conservative attitude toward the condition, and Campbell suggests a time limit in waiting for spontaneous regression. However, there remains in the minds of many today the problem of just which cases should be operated upon and which should be treated conservatively. Coley and Ewing described a case in which sarcomatous degeneration followed what was

apparently myositis ossificans, and they emphasized the need of biopsy if doubt of the true nature of the condition exists. Certainly it would be very unwise to delay biopsy of a bone sarcoma on the ground that it might be myositis ossificans. However, the diagnosis in the majority of cases is not difficult if the history is that of trauma or painful bruising, followed by the formation of a stonelike mass with roentgenographic findings as described by Noble.

The apparent frequency of myositis ossificans in the insane has been commented upon.

Following are the descriptions of the courses and pathological findings of cases which are considered to be excellent examples of the operative and non-operative types.

CASE REPORTS

CASE 1. F. B., a female, twenty-five years old, who was a manic depressive, fell against a bureau while in a manic state. She was seen promptly by staff members of the sanitarium where she was confined. Roentgenographic examination showed posterior dislocation of the left elbow. This was promptly reduced and the arm was placed in splints at 90 degrees of flexion. Fixation was interrupted by the non-cooperation of the patient, and the splints were finally removed after one month. At that time there was stiffness of the elbow joint, as well as pain on motion.

The patient remained in a depressed state for three months, refusing physiotherapy and holding the arm in about 135 degrees of extension. During this time there was no motion of the left elbow and the attending psychiatrist noticed that there was a consid-

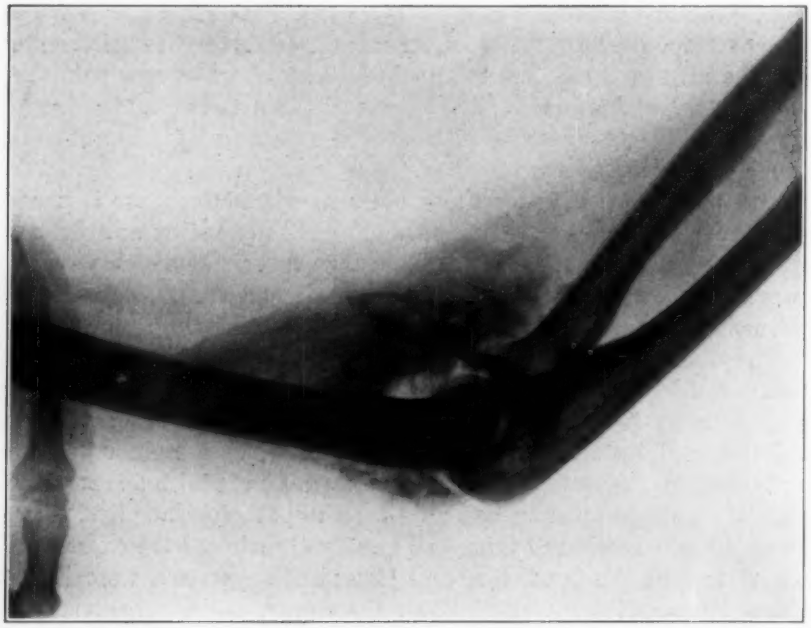


FIG. 1

Preoperative roentgenogram, showing extensive calcification of the brachialis anticus muscle.

erable amount of "stony induration" in the antecubital fossa. Examination showed a completely ankylosed elbow, allowing no flexion, extension, suppination, or pronation. In the antecubital fossa could be felt a sausage-shaped bony mass which, on palpation, was smooth and not tender. No motion of the elbow joint could be elicited with the exertion of great force. The bony landmarks were normal and it was easy to recognize the fact that the dislocation had been reduced. Myositis ossificans of the brachialis anticus muscle was suspected and verified by a roentgenogram (Fig. 1). The mass was observed and x-rayed regularly, but no change in the consistency of the mass or in the density of the shadow could be demonstrated. On account of the ankylosis, some concern was felt about the return of function, and when, after eight months' observation, no signs of regression were present, operation was decided upon.

General physical examination at this time revealed a depressed, but physically normal, young white woman. Positive findings were limited to the left elbow. The temperature was 98.6; the pulse, 80; and respirations, 20. The urine was negative. The blood count showed: hemoglobin, 85 per cent.; red blood cells, 4,600,000; white blood cells, 8,500. Calcium, phosphorus, and phosphatase tests revealed no deviation from the normal. The Wassermann test was negative.

Operation

Under ethylene anaesthesia, an incision was made over the lateral aspect of the upper arm, and continued across the antecubital fossa. The mass was located directly beneath the subcutaneous tissue. Immediately the musculospiral nerve was located, coursing along and apparently included in the substance of the mass. However, it was soon noticed that a few strands of muscle attached to the nerve had not undergone calcification—apparently nature's protection to the nerve itself—which simplified greatly the separation of the nerve from the mass. After the musculospiral nerve had been released, the mass was dissected free from other structures and it became evident that we were dealing with an almost complete ossification of the brachialis anticus muscle, extending from its firm attachment to the lower end of the humerus as far as its attachment on the upper end of the ulna. The humeral end was loosened with the chisel, and during this process the impression was gained that this bone was softer than normal cortical bone, as the sensation was that of cutting into cancellous bone. The mass could now be

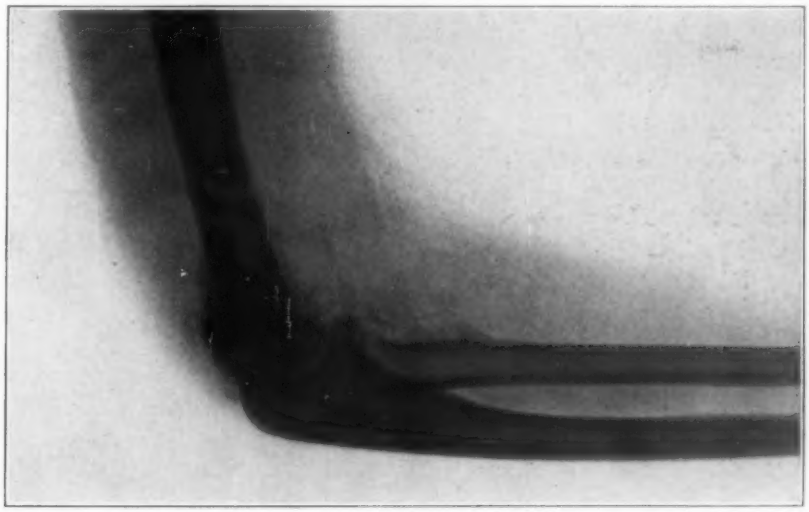


FIG. 2

Postoperative roentgenogram of the elbow shown in Fig. 1.

rocked slightly, but it was adherent to the anterior surface of the elbow joint by numerous fibrous bands. These were separated, and finally the entire ossified muscle was removed by chiseling it free from its ulnar attachment. The vessels were ligated and the wound was closed in layers. A cast was applied with the arm in a position of more than right-angle flexion. The cast was removed at the end of one month, following which physiotherapy, consisting of baking, massage, and passive and active motion, was begun.

Improvement was slow, but at the time of this report, five months after operation, there was slight limitation of full extension and of flexion, but practically no limitation of pronation and of suppination. The patient used the arm with ease and satisfaction for all her household duties, and had no pain. Postoperative roentgenograms (Fig. 2) showed no tendency to reappearance of ossification. Mentally the patient was normal.

Pathological Examination

Sections showed areas of degenerating muscle fibers with a considerable amount of fibrosis, osteoid tissue in which there were beginning lacunae, cartilaginous appearing cells, and, in places, what seemed to be ill-formed bone marrow. There were no giant cells, osteoclasts, or true osteoblasts. The resemblance to cancellous bone was striking. No evidences of regression were present in the slides (Figs. 3 and 4).

CASE 2. G. C., a male, thirty-six years of age, fell on the buttocks in November 1935. The injury was considered to be a bruise and, because of its minor character, the patient did not think it necessary to consult a physician. One month later, the swelling had persisted and, although no longer discolored, it had "become hard". At this time the patient consulted a physician, who told him that the swelling would disappear and advised him to apply heat. Upon failure of the swelling to disappear, six months after the injury, the patient again sought the advice of a physician and was seen by the author.

Examination revealed that the induration extended along the fibers of the gluteal muscle, that it was stony hard, and that it moved *en masse* when manipulated. Roentgenographic examination bore out the contention that we were dealing with myositis

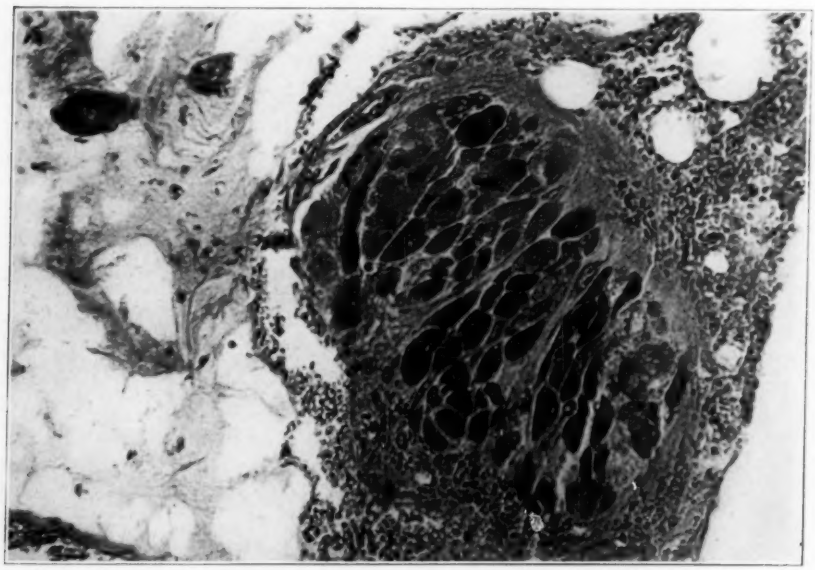


FIG. 3

Case 1. Section showing degenerated muscle fibers, bone formation, and fibrosis.

ossificans. While the patient was under observation for this condition, routine physical examination disclosed active bilateral pulmonary tuberculosis, and clinicians agreed that the lesion would be fatal. During the patient's stay in the isolation pavilion, the

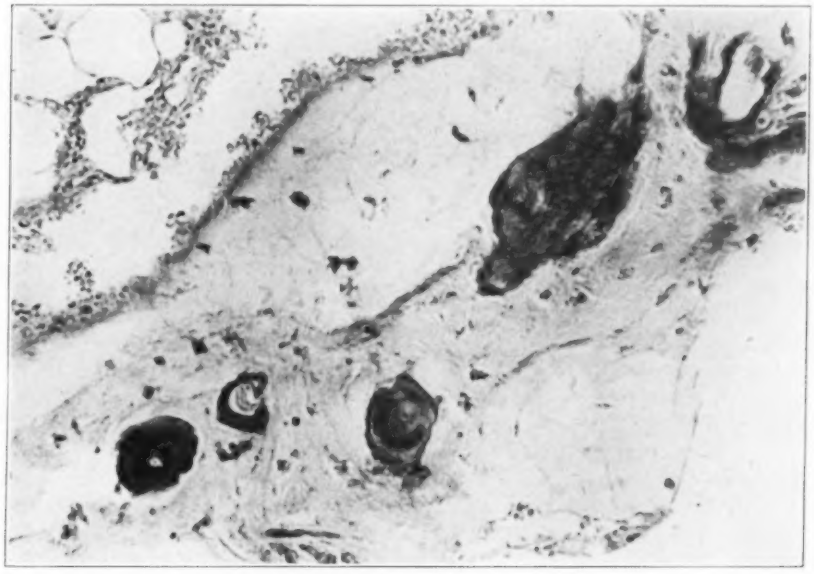


FIG. 4

Case 1. Section showing bone, lacunae, and fibrosis. Note the absence of osteoclasts and osteoblasts.

FIG. 5

Case 2. Gross specimen.

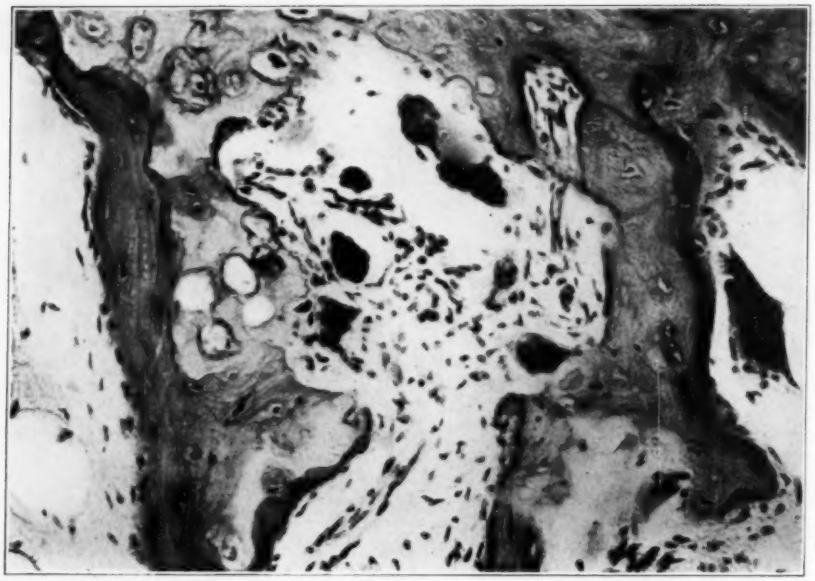


FIG. 6

Case 2. Section showing bone, lacunae, fibrosis, numerous giant osteoclastic cells, and cells resembling osteoblasts.

gluteal lesion was observed and two months after admission it was noted that the mass was smaller in size and softer in consistency; three weeks later it was still softer in consistency and gradually becoming smaller. This process of diminution and absorption was observed for five months, at the end of which time the patient succumbed to tuberculosis.

An autopsy was performed and the entire gluteal group was removed *en masse* (Fig. 5). Inspection of the mass, in which only a part of the muscle was involved, showed a striking resemblance to the exposed vertebrae during laminectomy. The bone had the appearance of cancellous bone and, when cut, resembled that kind of structure.

Pathological Examination

A very different picture was seen from that of the first case described. There was degeneration of muscle, showing fibrous and osteoid tissue with large nuclei, cartilaginous cells, and evidence of an attempt at bone-marrow formation. In all the sections, however, there were numerous giant cells and osteoclastic cells. A few osteoblastic cells were seen. The numerous osteoclastic cells were, of course, evidence of bone destruction. Since they were predominant over the osteoblasts, the pathological picture was believed to be one of absorption (Fig. 6).

SUMMARY

In the treatment of the condition known as myositis ossificans traumatica, the necessity of operation in cases of non-absorption and disability is stressed.

Comparison of the pathological findings showed a predominant number of giant or osteoclastic cells in the case in which absorption took place, while not one of these cells was present in the case demanding operation. These pathological pictures clearly parallel the clinical observations.

REFERENCES

CAMPBELL, E. R.: Traumatic Myositis Ossificans. Southern Med. J., XXVII, 763, 1934.

COLEY, W. B.: Myositis Ossificans Traumatica. A Report of Three Cases Illustrating the Difficulties of Diagnosis from Sarcoma. Ann. Surg., LVII, 305, 1913.

EWING, JAMES: Neoplastic Diseases. A Treatise on Tumors. Ed. 3. Philadelphia, W. B. Saunders Co., 1928.

FINNEY, J. M. T.: Myositis Ossificans Traumatica. Southern Med. J., III, 36, 1910.

LEWIS, DEAN: Myositis Ossificans. J. Am. Med. Assn., LXXX, 1281, 1923.

MCGUIRE, F. A.: Traumatic Myositis Ossificans. With Report of Case. Internat. J. Med. and Surg., XLIV, 321, 1931.

NOBLE, T. P.: Myositis Ossificans. A Clinical and Radiological Study. Surg. Gynec. Obstet., XXXIX, 795, 1924.

PAINTER, C. F.: A Consideration of the Etiologic Factors in Myositis Ossificans Traumatica. Boston Med. and Surg. J., CLXXXV, 45, 1921.

ROHDE, CARL: Does Bone Form from Osteoblasts or from a Metaplasia of the Surrounding Connective Tissue? Surg. Gynec. Obstet., XLI, 740, 1925.

EFFECT OF SYMPATHECTOMY ON THE LEG LENGTH IN CORTICAL RIGIDITY

BY STEELE F. STEWART, M.D., LOS ANGELES, CALIFORNIA

The work of Harris has drawn attention to the possible effect of sympathectomy in connection with the lengthening of short limbs in infantile paralysis.

In a very large series of sympathectomies done to correct the cortical rigidity of infancy, it has been possible to follow six patients upon whom sympathectomy was performed on only one side.

CASE 1. M. P., twelve years of age, with right brachio-skelic rigidity. In 1929, right cervical and lumbar sympathectomies were performed. No shortening of the leg was observed at the time of the operation. In July 1936, the right leg was one-half an inch longer than the left.

CASE 2. V. S., nine years of age, with right skelic rigidity. In 1930 a right lumbar sympathectomy was done. There was no observable difference in the length of the legs at the time of the operation or in July 1936.

CASE 3. B. L. S., four years of age, with left brachio-skelic rigidity. In 1930, left cervical and lumbar sympathectomies were performed. There was no observable difference in the length of the legs at the time of the operation or in 1936.

CASE 4. B. R., eleven years of age, with right cranio-brachio-skelic rigidity. In 1928, right cervical and lumbar sympathectomies were done. No observable difference in the length of the legs was present at the time of the operation or in 1936.

CASE 5. H. B., three years of age, with right brachio-skelic rigidity. In 1929, right cervical and lumbar sympathectomies were performed. No difference in the length of the legs was noted at the time of the operation. In 1936, the right leg was one-half an inch longer than the left.

CASE 6. A. S., six years of age, with left brachio-skelic rigidity. In 1927, left cervical and lumbar sympathectomies were done. No difference in the length of the legs was observed at the time of the operation or in July 1936.

In this fairly short series of cases a change in leg length occurred in only two patients and this to a relatively minor degree. Therefore, sympathectomy cannot be said to have much, if any, effect on the length of the extremities in cases of cortical rigidity.

AN UNUSUAL CASE OF POST-TRAUMATIC DECALCIFICATION OF THE BONES OF THE FOOT

BY B. SOUTAR SIMPSON, M.B., F.R.C.S. (EDIN.), GOLSPIE, SCOTLAND

Surgeon, Lawson Memorial Hospital, Golspie; Surgeon Consultant, County of Sutherland

The following case is one in which an unexpected and unusual degree of decalcification of the bones of the foot followed a moderately severe, localized, and comparatively common type of injury.

CASE REPORT

June 1926

A strong, healthy, active girl, aged fourteen years, of healthy parentage, and presenting no neurosis, tripped over a rope and came down heavily on the toes of the left foot. There was immediate pain of a severe and disabling character. On examination, the injury was found to be localized. Marked swelling and tenderness were limited to the tarsus and the metatarsus, and there was a strikingly well-defined line of bruising from the bases of the toes to the level of the midtarsal joint. There was no pain or constitutional disturbance.

After three weeks' rest, all signs of injury had disappeared and there was no disability.

April 1927

The patient complained of slight discomfort, thought to be due to "flat-foot". No abnormality was detected on roentgenographic or clinical examination. Massage, exercises, and sea-water bathing were advised, and the condition improved.

April 1928

While the foot was being massaged, intense pain was suddenly experienced at the lateral border. Examination showed definite muscle wasting in the left leg. There was acute tenderness toward the base of the fifth metatarsal, but the condition disclosed by the roentgenogram was as unexpected as it was surprising. The third, fourth, and fifth metatarsal bones, the cuneiforms, and the tarsal navicular had undergone such decalcification that they cast but little shadow and were attenuated in shape and deficient in detail. There was a fracture of the body of the fifth metatarsal. The right foot showed no abnormality, and roentgenographic examination of the knees, the hip joints, and the bones of the left leg in the neighborhood of the cartilages of the joints showed no alteration in bone structure.

After consultation with Prof. John Fraser, an attempt was made to correct an adduction deformity of the foot by means of a special boot. The administration of calcium and parathyroid was added to the existing treatment.

February 1929

Investigations undertaken by Prof. Fraser showed the blood calcium to be of normal quantity. The electric reactions of the muscles of the limbs, including the interossei and the plantar groups, were normal. A small portion of the fifth metatarsal was removed and examined. The bone lacked calcium and the cancellous spaces were enlarged. The ordinary marrow was entirely replaced by vascular fibrous tissue.

Roentgenograms were taken at regular intervals and showed a progressive increase in the decalcification. The foot became very unstable and useless, and so little tissue remained in the lateral half that the finger and thumb could be made to meet from

dorsum to sole. Distal to the mediotarsal joint there was a cyanotic tint; a growth of downy hair appeared; and a constant localized hyperhidrosis was present.

The question of possible benefit from periarterial sympathectomy was considered at this time, but in this case the operation was thought not to be justifiable. Bier's hyperaemia was used daily.

FIG. 1-A

FIG. 1-B

1928. Anteroposterior and lateral views of left foot, showing decalcification of the metatarsal and of the midtarsal bones and a pathological fracture of the fifth metatarsal.

August 1929

At this time definite clinical improvement was noted,—the sweating was less marked, and the foot felt warmer and was more stable. The tissue deficiency was replaced to a certain extent by what felt like "sponge rubber". Walking had improved also, but, despite these reassuring signs, roentgenographic examination indicated an increase in the decalcification.

July 1931

At examination, five years after the original injury, the outline of the fifth metatarsal could not be distinguished and there was no bony substance in the third and fourth metatarsals. The shadow of the second metatarsal appeared more dense than two years previously. The patient was able to play nine holes of golf without undue fatigue. A slight injury, when the forepart of the foot was twisted between two planks, temporarily increased the disability, but, after a course of massage, with exposures to ultra-violet and infra-red rays, some improvement was seen in the muscles of the leg and foot.

1932

Local examination at this time showed that the foot had increased in length and in breadth. A slight degree of talipes calcaneocavus had developed; the tendency to adduction on walking was easy to correct, but most difficult to control efficiently. The temperature of the foot was normal, and excessive perspiration had ceased. Palpation of the metatarsal and

midtarsal regions showed distinctly that more resistance and solidity were present than a year previously. Roentgenograms showed a deformation of the talus and the calcaneum. The borders of their approximate surfaces were lipped and projecting, associated with apparently abnormal excavations.

1933–1936

During this period clinical improvement has been maintained. The patient walks and cycles freely, and states that she can play eighteen holes of golf and even dance in comfort.

On examination the foot shows no trophic disturbances or muscle weakness. The remaining bony tissues of the tarsus and of the metatarsus on the medial aspect have consolidated, forming a fixed adduction deformity. The lateral part of the foot contains no palpable bony tissue, but has definite stability. In spite of this improvement in function and in stability of the foot, an inspection of the most recent roentgenograms makes it impossible to say that the condition is completely arrested, although some of the remaining bones show denser shadows, suggesting areas of recalcification.

FIG. 2

1930. Progressive decalcification. The outlines of several bones are barely distinguishable.

FIG. 3

1932. Gradual disappearance of the third, fourth, and fifth metatarsals.

SUMMARY OF CASE

This case has been under observation during a period of ten years. The history may be summarized as follows:

June 1926: Localized injury to foot.

April 1927: Slight discomfort with "flat-foot". No abnormality discovered.

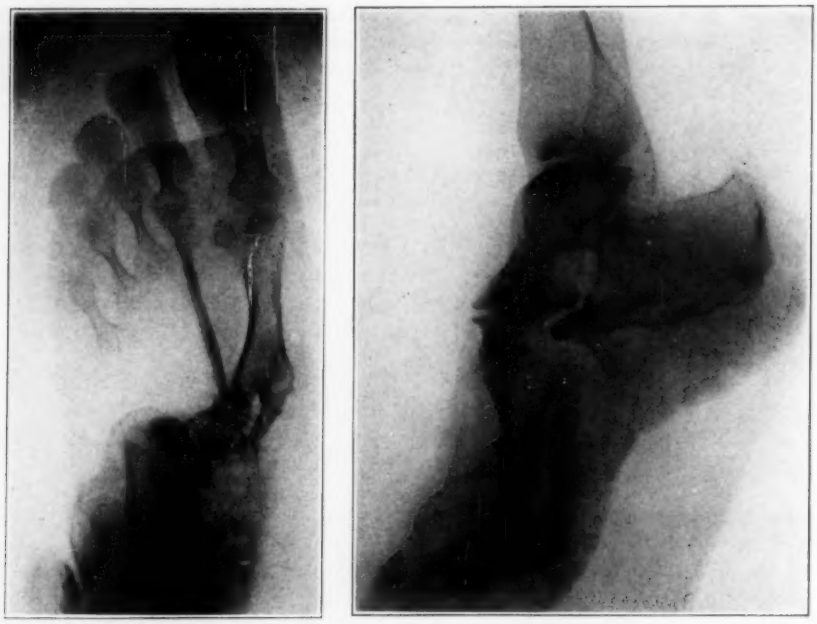


FIG. 4-A FIG. 4-B

1935. Complete absorption of the third, fourth, and fifth metatarsals and of the midtarsal bones. Marked deformation of the talus and of the calcaneum. Points of denser shadow suggest attempts at recalcification in the remaining bones.

April 1928: Roentgenograms showing absorption of bones with pathological fracture of the fifth metatarsal.

1928–1933: Slow evolution with progressive decalcification as shown by roentgenograms.

1933–1936: Replacement of absorbed bones by tissue which has produced increasing stability and usefulness of the foot.

DISCUSSION

All those who examined the earlier roentgenograms in this case were agreed that the extreme degree of decalcification was most unusual and difficult to explain. Various suggestions were made: that the nature of the bone changes was on a parallel with the arthropathy seen in conjunction with certain nervous diseases; that there was a question of parathyroid tumor and hyperparathyroidism; that a spinal lesion, such as a spina bifida occulta, was present (the roentgenogram of the lumbar region showed no abnormality), etc. After careful local and general investigations had been carried out without helpful results, it was clear that the progressive decalcification and its localization in an otherwise healthy girl could not be dissociated from the injury sustained in 1926.

Sudeck first directed attention to the condition of post-traumatic decalcification in 1900, but the importance and far-reaching consequences of such disturbances of bone structure are only now being appreciated.

The recognition of the significance of these disturbances is due chiefly to the work of Leriche and his collaborators on the Continent, and of D. M. Greig in Scotland. Recently Middleton and Bruce published an interesting paper on "Post-Traumatic Osteodystrophy at Joints", based on a series of twenty cases.

As far as can be ascertained, no other case has been reported in the literature, which shows such an extreme degree of decalcification progressing over a period of so many years after the localized injury. Although the initial injury was probably more severe than was realized at the time, there was almost complete absence of pain throughout. In this respect the condition differs from the "post-traumatic painful osteoporosis" of Leriche and Fontaine.

Etiology

It is now generally accepted that decalcification is accompanied by hyperaemia. In this case hyperaemia was locally induced by injury, and certain bone changes might readily have followed, but no explanation can be given for the progressive decalcification of some bones and the actual absorption of others over such a prolonged period. It seems certain that injury caused a disturbance of the autonomic nervous system controlling the local blood supply, and it may be, as Greig suggests, that some alteration of an endosecretion added a centrally induced hyperaemia to prolong the process.

Prognosis

It is impossible to foretell whether or not recalcification can yet occur in the remaining bones of the foot. It is certain, however, that bones which have been absorbed are being replaced by tissues which cannot be seen roentgenographically, but which have sufficiently definite stability to give a functionally useful foot.

The author wishes to express his appreciation to Prof. John Fraser for his continued interest in this case, and also for permission to quote the results of investigations made while the patient was under his care in the Royal Infirmary, Edinburgh. Many helpful suggestions were also received from the late Mr. D. M. Greig, Curator of the Museum, Royal College of Surgeons, Edinburgh.

REFERENCES

GREIG, D. M.: Clinical Observations on the Surgical Pathology of Bone, p. 227. Edinburgh, Oliver and Boyd, 1931.

LERICHE, R., ET FONTAINE, R.: Des ostéoporoses douloureuses post-traumatiques. Presse Méd., XXXVIII, 617, 1930.

MIDDLETON, D. S., AND BRUCE, JOHN: Post-Traumatic Osteodystrophy at Joints. Edinburgh Med. J., XLI, (Trans. Med.-Chir. Soc. Edinburgh) 49, 1934.

SUDECK, P.: Ueber die acute entzündliche Knochenatrophie. Arch. f. klin. Chir., LXII, 147, 1900.

OSTEOGENESIS IMPERFECTA

Report of a Case in an Adult

BY EDWARD PARNALL, M.D., ROCHESTER, NEW YORK

W. W., male, twenty-eight years old, an office worker, was sent to the writer with a complaint of pain in the dorsal spine and the feet, and inability to extend fully the left knee.

During early life and adolescence the patient had sustained seventeen fractures, involving every long bone in his body at least once. All of these fractures had healed uneventfully. There had been no fractures since the patient was about twenty years old. The trauma causing the fractures had nearly always been of a very trivial nature. During the two years prior to examination the patient had been increasingly troubled by a lame and bowed back, with pain especially on driving in an automobile. The fact that he could not fully extend the left knee seemed to throw him off balance in walking, and caused more back pain.

The patient presented a gnomelike appearance, standing with bowed back and holding his head, with pointed triangular face, down on his chest. He was obviously deaf, and the sclera of his eyes were a dusky blue. He walked with a left-sided list, due to a 30-degree flexion deformity of the left knee.

All the long bones showed obvious evidence of having been fractured. The alignment of the tibiae was such that the feet were kept in moderate valgus and continuously

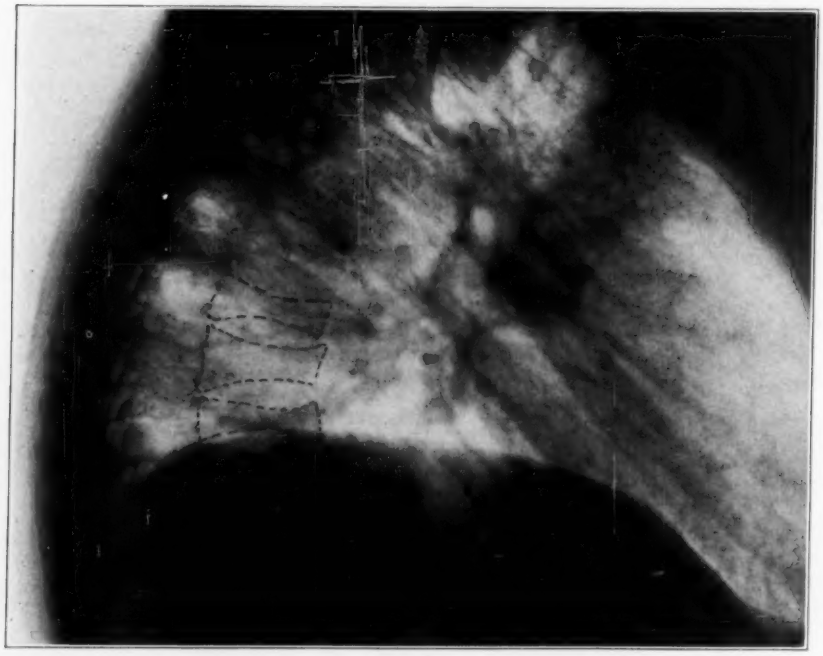


FIG. 1

Lateral view of dorsal vertebrae. The dotted lines bring out the amphicelous or biconcave appearance of three vertebrae. The same appearance is faintly visible in the other vertebrae.

strained. The knee lacked 30 degrees of full extension, even with forcing, which manoeuver caused pain. Obstruction seemed due to bony block.

There was considerable dorsal kyphos, especially at about the sixth dorsal vertebra, with pain on any attempt at hyperextension.

Roentgenograms showed generalized osteoporosis. The vertebrae were amphicelous, or "fishlike", in appearance, due to pressure from the intervertebral discs, with a considerable amount of wedging in the dorsal region. Roentgenograms of the left knee showed a block of bone lodged in front of the femur, just above the patella (presumably an old fracture which the patient had forgotten to mention).

The patient felt that he did not care to undergo operative removal of the bony fragment from the knee, and was put on a regimen of hyperextension, periodic rest, hot packs to the knee, and foot plates. Conservative treatment relieved the condition a little for about two months, at the end of which time the patient strained his back. He then readily agreed to enter the hospital.

The knee was explored, and it was found that the block of bone was indeed the upper fragment of the patella. This block was easily removed. After a few days the patient was placed upon a hyperextension frame, and the curve was gradually increased. At the end of two weeks the patient was fitted with a Taylor back brace, and discharged at the end of five weeks.

Calcium and phosphorus determinations were well within normal limits.

The patient gradually increased his activity, returning to work twelve months after operation. The brace was discarded after sixteen months. At times he had some trouble with the knee which had been operated upon, but this always cleared up with exercises. At the end of two and one-half years, he was able to work actively, to walk without a list, and to drive about in his car.

In this case, strangely enough, there is no history of any fractures nor of any blue sclera in other members of the family, as far back as can be determined. The only familial sign is deafness in the mother of the patient.

UNUNITED FRACTURES TREATED BY BONE DRILLING

BY E. R. EASTON, M. D., AND PRO. V. PREWITT, M. D., NEW YORK, N. Y.

From the Surgical Service of the Knickerbocker Hospital, New York City

Delayed union or non-union of fractures of the long bones, resulting from various causes, is not uncommon. The method of drilling to secure bony union has been used in numerous cases at Knickerbocker Hospital with uniformly good results.

Indications for this operation are:

1. Persistent mobility;
2. Malposition of the fragments, as shown by the roentgenogram;
3. Lack of proper calcification.

The following nine selected cases represent a variety of conditions to which the method is applicable.

CASE 1. A. J., male, twenty years of age, an office boy, fell down an elevator shaft in 1930 and sustained a compound fracture of the middle third of the left tibia and a double fracture of the upper and lower portions of the left fibula. A slide graft was used in 1931. This graft absorbed, and in 1932 the tibia was pierced ten or twelve times with a bone drill. Solid bony union occurred after three months.

CASE 2. A. U., female, aged sixty-one, a housewife, slipped and fell on the left side, fracturing the neck of the left femur. The fracture was reduced and a plaster spica was worn for eight weeks. At the end of this period there was no union, and distinct slipping of the fragments was observed. Four days after reduction and retention with a Jones traction splint, the hip was drilled according to the technique of Bozsan. The splint was left in place for sixteen weeks; walking calipers were then applied. Roentgenographic examination, one year after operation, showed firm bony union with some absorption of the neck.

CASE 3. E. L., female, aged fifty-four, a housewife, fell in December 1934 and fractured the surgical neck of the left humerus. Open reduction was performed on February 26, 1935, and the coracobrachialis and short head of the biceps were found interposed between the fragments. The fragments were pierced eight or ten times with a drill and fixed with two Easton nails* which were removed at the end of two months. A roentgenogram, taken on April 10, 1935, demonstrated solid bony union.

CASE 4. V. P., female, a housewife, sustained a compound fracture of the left tibia and fibula at the junction of the upper and middle thirds. Union was delayed. The fragments were drilled by Dr. J. V. Bohrer and solid bony union was present after six weeks.

CASE 5. F. C., female, fifty-five years old, a nurse, fell on September 21, 1935, and fractured the right tibia and fibula at the junction of the middle and lower thirds. The patient was treated by cast in another hospital, and was discharged after three weeks. The cast was removed at the end of five weeks, and the patient was permitted to bear weight on the foot. Non-union resulted. The Wassermann test was three plus. The fragments were drilled on December 3, 1935, and a cast was applied. This cast was

* Triangular steel nails which can be driven into some of the drill holes, thus holding the fragments in alignment until satisfactory union has taken place.

worn for six weeks; during the last three weeks the patient was permitted to walk. At the end of six weeks solid bony union was present.

CASE 6. J. M., male, aged seventeen, was thrown from a motorcycle on February 7, 1934, and sustained a compound comminuted fracture of the right tibia and fibula at the junction of the middle and lower thirds. Nine months later, October 14, 1934, upon discharge from the hospital, examination showed posterior bowing, mobility, exuberant callus, and no calcification demonstrable by x-ray. These findings were present up to March 2, 1935, when the fracture was drilled by one of us (P. V. P.). Roentgenographic examination gave evidence of increasing bony union, although mobility was still present. On July 16, 1935, union was firm; there was no mobility; and calcification was evident in the roentgenograms.

CASE 7. G. W., male, fifty-four years old, a janitor, fell down a flight of stairs, fracturing the tibia and fibula in the distal thirds. There was considerable injury to the soft parts. Traction was maintained for one month by the Steinmann pin, followed by immobilization in a plaster cast. There was no evidence of union at the end of three months. Three weeks after drilling and immobilization in a plaster cast, union was firm.

CASE 8. N. C., a female, aged fifty-nine, fell on the sidewalk on November 7, 1935, fracturing the neck of the femur at its midportion. Eleven days after reduction by the Leadbetter method and application of a plaster spica, the fragments were drilled and fixed with Easton nails to prevent delayed union or non-union. The nails were removed seventy-two days later. The cast was taken off one month after removal of the nails, at which time there was roentgenographic evidence of early union. On June 15, 1936, the patient walked without support. The roentgenogram showed firm union at the fracture site.

CASE 9. B. W., a female, fell on January 28, 1936, sustaining a subcapital fracture of the neck of the femur. The Wassermann test was three plus. The fracture was reduced by a combination of the Murray and the Leadbetter methods, and a plaster spica was applied. Two weeks after reduction, the fragments were drilled and two Easton nails were inserted through a window in the cast to prevent delayed union or non-union. On June 30, the patient walked without support. The roentgenogram showed firm union at the fracture site.

The chief advantages of the drilling operation, as observed by the authors, are: (1) it creates an aseptic inflammatory process which increases local circulation; (2) pulverized bone is deposited within the fracture area; and (3) the viable cells promote the formation of so called "bony callus".

In the presence of active inflammation, the operation is contra-indicated, and should not be performed until it subsides. No other contra-indication has been observed.

SUMMARY

The authors have found that the bone-drilling operation involves less risk than the more formidable operations, and brings about more rapid union and gives more satisfactory results than any other method so far employed.

A METHOD OF TREATING FRACTURE OF THE CLAVICLE

BY GEORGE W. HAWLEY, M.D., F.A.C.S., BRIDGEPORT, CONNECTICUT

From the Orthopaedic and Fracture Service of the Bridgeport Hospital

The surgical objective in the treatment of fracture of the clavicle is to force the head of the humerus backward and with it the scapula, to which the outer end of the clavicle is attached. This has the effect of traction on the broken bone and avoids overriding and angulation of the fracture ends.

For the past ten years the following method has been used and has been found very satisfactory. It is carried out as follows. The patient, either standing or sitting on a stool, is requested to hold his head erect and to square his shoulders like a West Point cadet. The end of a strip of adhesive plaster is fastened to the skin in front of the head of the humerus. The opposite arm in abduction is pulled into hyperextension and used as a lever, while the plaster under strong tension is anchored to the opposite chest wall. This acts to pull the shoulder girdle back and to hold it securely. Several strips of plaster are applied in like manner, using a double thickness of plaster for added strength. As a rule, adhesive plaster is not effective unless it is at least of double thickness. Then a cap of adhesive is applied over the shoulder to anchor the anterior ends of the first plaster and to protect the site of

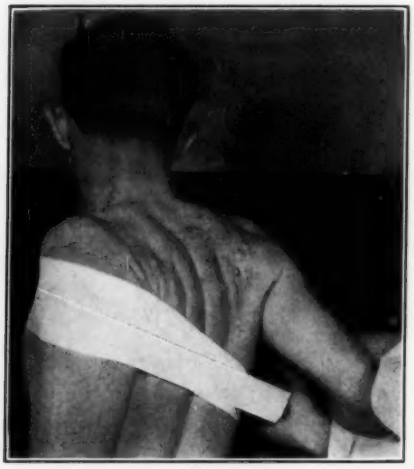


FIG. 1

Showing the method of applying the strips of adhesive plaster to exert a strong, backward pull on the shoulder girdle, using the opposite arm as a powerful lever.

FIG. 2

Showing the adhesive plaster in place as seen from behind. Note the pulling back of the shoulder girdle and how securely the position is held, also that the shoulder girdle is automatically elevated as the shoulder is retracted, preventing forward pull of the pectoral muscles and sagging of the outer fragment of the clavicle, due to gravity.

fracture. For the first week the arm is carried in a sling, following which the patient is allowed to take the arm out of the sling for meals. The sling is discarded when healing is under way and confidence returns. The plaster is reapplied every week for three to four weeks, using the same tension to hold the reduction.

FIG. 3

View from in front with the adhesive strips over the shoulder.

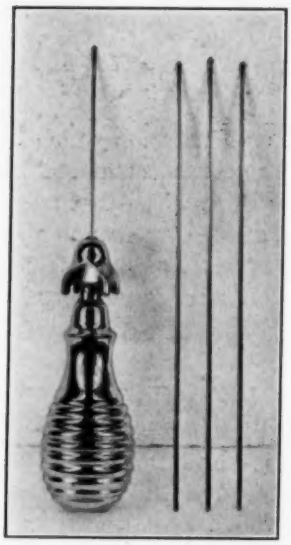
Some of the advantages of this method are these. It is simple and requires only ordinary adhesive plaster. It effects good reduction and holds the reduction. It requires no constant watchfulness and frequent adjustment; only weekly replacement is necessary. The chief objection to this method is that which applies to the use of any adhesive plaster,—the discomfort and irritation which it causes some individuals, although there are few who cannot comfortably stand it for the time required. For several years this method has been used as a routine with entire satisfaction. In rare cases, when union is complete and, in spite of all efforts to control it, the sharp end of one fragment insists on projecting upward, leaving an unsightly cosmetic blemish, the upper surface of the clavicle is smoothed off with a chisel through a small incision, with very satisfactory results.

AN INSTRUMENT FOR THE INSERTION OF KIRSCHNER WIRE IN PHALANGES FOR SKELETAL TRACTION

BY D. M. MEEKISON, M.B.(TOR.); B.SC., F.A.C.S.,
VANCOUVER, B. C., CANADA

The instrument described and illustrated below has been designed to facilitate the application of skeletal traction to fingers, particularly in treating compound fractures of the proximal phalanges. Nails, needles, and wires once placed have proved effective, but their insertion, either anteroposteriorly through the center of the finger-nail and the terminal phalanx, or laterally through the distal portion of the middle phalanx, has usually been extremely difficult.

The heaviest type of Kirschner wire has been selected as the most satisfactory material for use with this instrument. It is cut in appropriate lengths and the end is flattened and sharpened for cutting both clockwise and counter-clockwise. The handle of the instrument, of a form suggested by the graver of an etcher, is bulb-shaped and it nicely fits the palm. It has a special and rather stout chuck operated by a winged nut. This chuck firmly grips the Kirschner wire which inserts to the base of the handle for steadiness. Using a wooden chopping block (as for Hoke's arthrodesis) against the side or palmar aspect of the finger, it is a simple matter to push or to rotate the wire through, to remove the handle, and to cut off the excess wire. Incidentally a music-wire cutter has been found extremely useful for this purpose. It should be pointed out that traction to the wire of the banjo splint should be made by means of two elastic bands, one on either side of the finger. This precludes the possibility of pressure from an encircling band.



Skeletal traction thus inserted has also been found useful when applied to the thumb in cases of comminuted fractures of the lower end of the radius. In these cases traction has been maintained in the direct line of the radius to a heavy wire incorporated in the plaster. This produces almost exactly the Cotton-Loder position if directed a little ventrally, and it has undoubtedly prevented a possible occasional unhappy result in fractures of the wrist.

The writer is indebted to Dr. D. A. Murray of Seattle for the original idea of traction on the thumb in comminuted fractures of the lower end of the radius, but his dexterity in the use of adhesive tape could not be duplicated by the author,—hence the skeletal traction.

The trauma incidental to insertion of the wire has so far produced no ill effects, and such traction has not appeared to cause the patients any unusual discomfort.

CARE OF THE FEET AFTER BUNIONECTOMY

BY LEO J. MILTNER, M.D., PEIPING, CHINA

From the Division of Orthopaedic Surgery, Department of Surgery, Peiping Union Medical College, Peiping, China

Following bunionectomy, an important part of the physiotherapeutic care of the feet is the reeducation and redevelopment of the intrinsic muscles of the feet, especially of the interossei, of the abductor digiti quinti, and of the abductor hallucis. Correct footwear is necessary, but, even though worn, it will not necessarily prevent a recurrence of the deformity unless the small muscles governing the toes are restored to power. Therefore, after operation, the patient should be instructed to perform a long course of exercises. In many instances, before operation almost complete atrophy of the intrinsic muscles may be seen; after operation and two or three months of exercises, these same muscles usually show a very surprising return of active ability to adduct and abduct the toes.

The accompanying photographs illustrate the Japanese type of stocking and sandal, the use of which has proved very helpful in carrying out the above exercises. With this slipper, the patient is enabled to walk as soon as the wounds are healed. The elastic straps hold the great toe in the desired position of correction during walking. In addition, the toes are allowed considerable freedom, so that during walking the patient may perform active exercises, especially adduction and abduction of the toes. Even after the patient has been fitted with shoes, these sandals may be used to advantage at home in place of the ordinary house slippers.

FIG. 1

The sandals have soles of felt and leather, with corrective elastic straps which separate the great toe from the second toe. Heels may be used if necessary.

FIG. 2

After bilateral removal of exostoses from the heads of the first and fifth metatarsals.

FIG. 3

The patient is wearing the special stockings and sandals, two weeks after bunionectomy operations.

A SELF-RETAINING BONE RETRACTOR

BY H. THEODORE SIMON, M.D., F.A.C.S., NEW ORLEANS, LOUISIANA

From the Department of Orthopaedic Surgery, Louisiana State University Medical Center, New Orleans

The writer designed this simple bone instrument, and has used it for a number of years with most satisfactory results. He feels that it should be described and made available for more general use.

The retractors are made of strips of sixteen-gage steel, bent in the form shown in Figure 1, to which are attached brass weights. The steel strips are spring-tempered. It has been found that three sizes are satisfactory for use in general bone surgery; however, any number of sizes could be made. The small size is made of a steel strip, six and one-half inches in length and three-quarters of an inch in width, with a weight of three and one-half ounces. The medium size is made of a strip, eight inches long and one inch wide, with a weight of six ounces. The large size is made of a nine-inch steel strip, one and one-eighth inches wide, with an eight-ounce weight. It should be noted that the curves in the rounded ends of the steel strips are made so as to cup into each other when slipped around the bone (Fig. 2). Two mated retractors make a complete instrument.

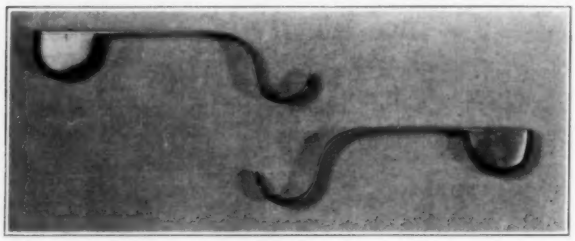


FIG. 1

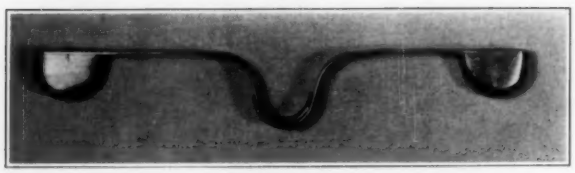


FIG. 2

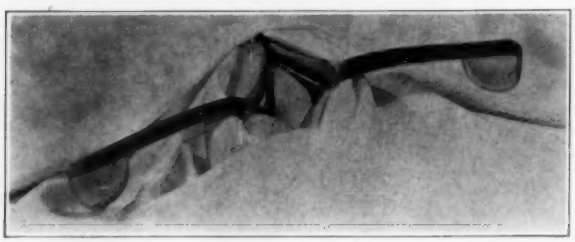


FIG. 3

The instrument has a threefold usage, acting as:

1. An elevator for the posterior periosteum;
2. A self-retaining bone retractor, eliminating one or more assistants;
3. An excellent protection for the soft parts, while the bone is being drilled, cut, and sawed.

A SELECTION OF KNOTS FOR USE WITH TRACTION-SUSPENSION APPARATUS

BY WM. DONALD DAVIDSON, M.D., EVANSVILLE, INDIANA

To be suitable for use with traction-suspension apparatus, a knot should be: (1) as simple as possible; (2) easily tied; (3) subject neither to slipping nor to jamming when in use; (4) easily untied when tension is relieved; and (5) neat in appearance. The following selection of knots is offered as having met these requirements in actual use.

The four basic knots in this selection are: the magnus hitch, the sheet-bend, the lark's-head, and the figure-of-eight. From the last, the packer's knot may be formed, while the bowline knot is fashioned from the sheet-bend. The operator should complete each knot by laying the free end of the cord beside the standing part, and by seizing them with a strip of adhesive wide enough to encircle both. This further reenforces the knot and gives it a neat and finished appearance.

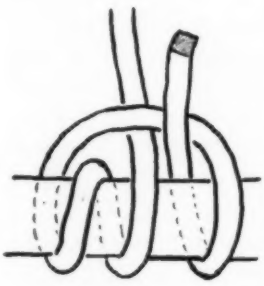


FIG. 1

Magnus hitch. Note all turns pass in same direction.

The magnus hitch (Fig. 1) is used to attach a cord to a splint or to a frame. It holds firmly without slipping, even when the strain is almost parallel to the bar. Two turns of the cord are made about the bar, and the free end of the cord is passed across in front of the standing part after the second turn has been completed. It is then carried about the bar, in the same direction as in the previous turns, to form a third turn. To complete the knot, the free end is brought up through the transverse portion of the cord and laid beside the standing portion. The knot must be drawn much tighter than that shown in Figure 1, which was purposely drawn loose for illustrative purposes.

The sheet-bend, or weaver's knot (Figs. 2, 3, and 4), is useful in joining two cords, either to give length or to attach the overhead suspension cord to the shorter cords, passing from one bar to the other on a Thomas splint. To give length, the free ends of two cords are crossed, and their point of junction is grasped with the left thumb and index finger. The left-hand cord, *A*, must be laid on top of the right-hand cord, *B*, as shown in Figure 2. With a flip of the right hand, a bight is thrown in *B*, passing it completely about its own free end and in front of the free end

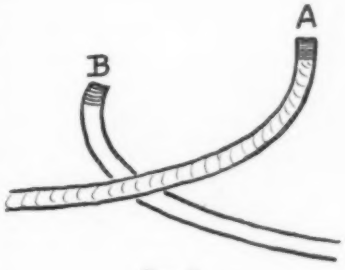


FIG. 2

Sheet-bend. Initial position. Left-hand rope on top.

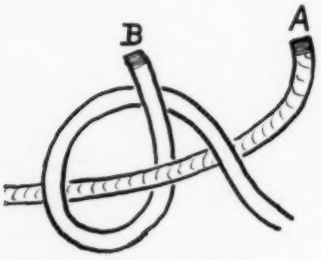


FIG. 3

Sheet-bend. Free end *A* projects through a bight thrown in *B*.

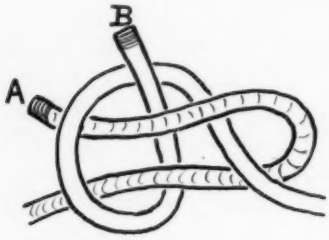


FIG. 4

Sheet-bend. Completed knot.

of *A* (Fig. 3). Free end *A* is then doubled back through this bight and grasped with the left hand, and the knot is tightened (Fig. 4). When used to fasten the overhead suspension cord to the shorter transverse cord, a bight is formed in the latter by grasping it so that the bight projects between the left thumb and the index finger; this bight takes the end position of cord *A*. The free end of the overhead suspension rope is brought through the bight, completely about the bight, and finally up through the loop thus formed. If cords of unequal size are to be joined, the larger of the two must be used as *A*.

The lark's-head knot (Fig. 5) is used to fasten a pulley ring to a cord. Both ends of a short length of cord are cut on a bias and rubbed on a cake of damp soap. They are then passed together through the ring, and the pulley is drawn along the doubled cord until only a small bight remains. The free ends are doubled back through the bight, and the knot is drawn tight. The pulley is then fastened to the Balkan frame by a magnus hitch in either end of the cord. If the axis of the pulley is to be the same as that of the bar to which it is attached, the hitches are thrown in opposing directions; if the axis of the pulley is to be at right angles to the bar, both hitches are passed in the same direction.

The figure-of-eight knot (Fig. 6) serves as a stopper knot, preventing a cord from pulling back through a spreader bar. The free end is doubled back and passed about the standing part and down through the bight. This knot has been employed, since it holds firmly, yet does not jam, and can be easily removed.

FIG. 5

Lark's-head knot.

The packer's knot (Fig. 7) gives a running loop, and is used in attaching weights for traction. It is formed from the figure-of-eight knot. A large loop is formed by passing the free end of a cord about the standing part, and then fashioning a figure-of-eight knot, using the cord of the loop as the standing part. The packer's knot is more secure than the ordinary slip knot which is commonly used.

The bowline knot (Figs. 8 and 9) forms a fixed loop. It gives an excellent

FIG. 6

Figure-of-eight knot.

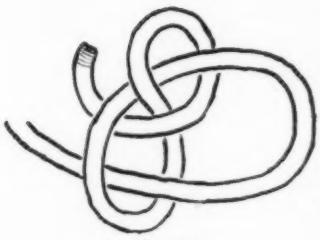


FIG. 7
Packer's knot.

hand grip. A short length of pipe may be threaded on the cord before the knot is tied, to give a better grasp. The knot is formed by making a large loop, by crossing the free end of the cord in front of the standing part. This crossing *a* is grasped with the right hand, palm down. The left hand, also palm down, grasps the proximal part of the loop some distance from *a*. The right hand is then turned palm up, carrying the free end around and up through the large loop (Fig. 8). A small bight is thus formed in the standing part, through which the free end projects. The crossing *c* is grasped with the left thumb and the index finger. The free end of the cord is carried around behind the standing part and down through the small bight to complete the knot (Fig. 9). It will be noticed that a sheet-bend has been formed in the cord. The running-bowline knot (Fig. 10) is formed by making a large loop, passing the free end of the cord around the standing part, and fashioning the bowline knot by making the small bight along the course of the large loop, and then completing the knot. This is the same procedure followed in fashioning the packer's knot from the figure-of-eight knot.

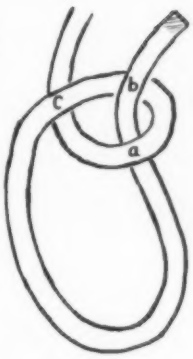


FIG. 8
Bowline knot. The small bight has been thrown in the standing part.

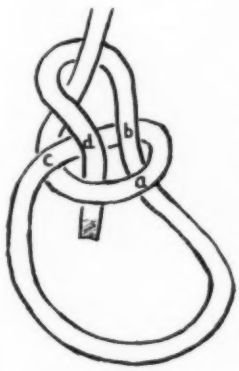


FIG. 9
Bowline knot. Completed form.

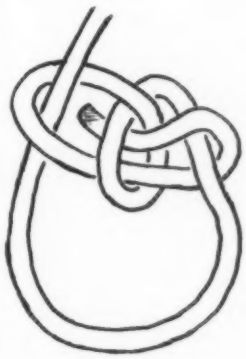


FIG. 10
Running-bowline knot.

With these simple knots, a traction-suspension apparatus may be set up with the assurance that slipping will not occur. While it is true that other knots may serve equally well, this selection meets every need. Since the knots are as simple as they are effective, they may be applied without difficulty.

A LEATHER TOE SPLINT *

BY A. M. RECHTMAN, M.D., F.A.C.S., PHILADELPHIA, PENNSYLVANIA

The toe splint shown in Figure 1 is used to supplant the cumbersome dressings commonly used to hold one or more toes in a proper attitude. This splint is simple to construct and easy to apply, and it occupies little space.

The splint is made from a single thin piece of walking *Leder* (imported German walking leather), one-sixteenth of an inch in thickness. It is firm but not rigid. The splint is constructed to conform approximately to the shape of the distal part of the sole of the foot, and it extends from directly back of the ends of the toes to the area beneath the metatarsal heads. The splint is fashioned somewhat smaller than the area of the sole of the foot to which it is fitted so that it will not be displaced by the stocking or by the shoe.

FIG. 1

Showing the splint in use. The patient, a male, aged fifty-four years, had had poliomyelitis. The right fifth toe was hyperextended. The extensor tendon was tenotomized. The left second toe was flaccid and plantar-flexed, with a painful callus on the distal end.

Two slits, three-fourths of an inch in length and parallel to each other, are cut in the support,—one upon either side of where the toe is to rest on the support. A piece of tape, three and one-half inches in length and five-eighths of an inch in width, is stitched to the under surface of the support and brought through the slit in the leather immediately adjacent. The tape is looped, so that it may be brought over the toe, and the end of the tape is brought through the second slit. The slits are cut sufficiently narrow to hold the tape firmly. Thus, the corrected attitude of the toe is maintained and no other fixation is necessary.

The splint is simple in construction and can be made by a leather worker or by a shoe-repair man. The physician may trim the toe splint with bandage scissors so that it will fit the foot.

The patient soon becomes accustomed to the presence of the splint on the foot and it may be worn with comfort. It has frequently been

* From the Orthopaedic Services of the writer at the Jewish Hospital, Philadelphia, at the Atlantic City Hospital, and at the Coatesville Hospital.

fitted to the feet of patients wearing Whitman plates. With the heat, moisture, and weight of the body, the splint soon conforms to the shape of the foot. It may be fashioned to fit any shaped foot, and one or more toes may be splinted. For hygienic reasons, it is advisable to have the splint made in duplicate, each to be worn on alternate days.

The splint has been successfully used as an aid in treating various congenital and acquired deformities of the toes and as a postoperative support to assist in maintaining the toes in a more normal attitude. Some of the specific conditions for which this toe splint has been used as an aid in treatment are: overlapping and underlying toes; dorsally hyperextended and dislocated toes (to relieve pressure); and hammer toes and bunions (as a preoperative and postoperative dressing). A preliminary tenotomy of the flexor or extensor tendons of the affected toe may at times be advisable before the splint is applied.

AN ADAPTED BANJO SPLINT

BY ROBERT ALAN HICKS, M.D., TUCSON, ARIZONA

There is a constantly growing conviction among those treating arthritis that one of the major contributions which the physician can make to the patient is the prevention of deformity. Simple position, manual reduction, etc., will not usually accomplish this end. Traction is of enormous assistance. In every patient with chronic proliferative arthritis the development of the earliest or slightest tendency to fusiform fingers should warn the practitioner that ulnar deviation in the metacarpophalangeal joints may develop in the near future, with never-to-be-corrected erosion of the lateral bony prominences at these joints. At the same time, flexion

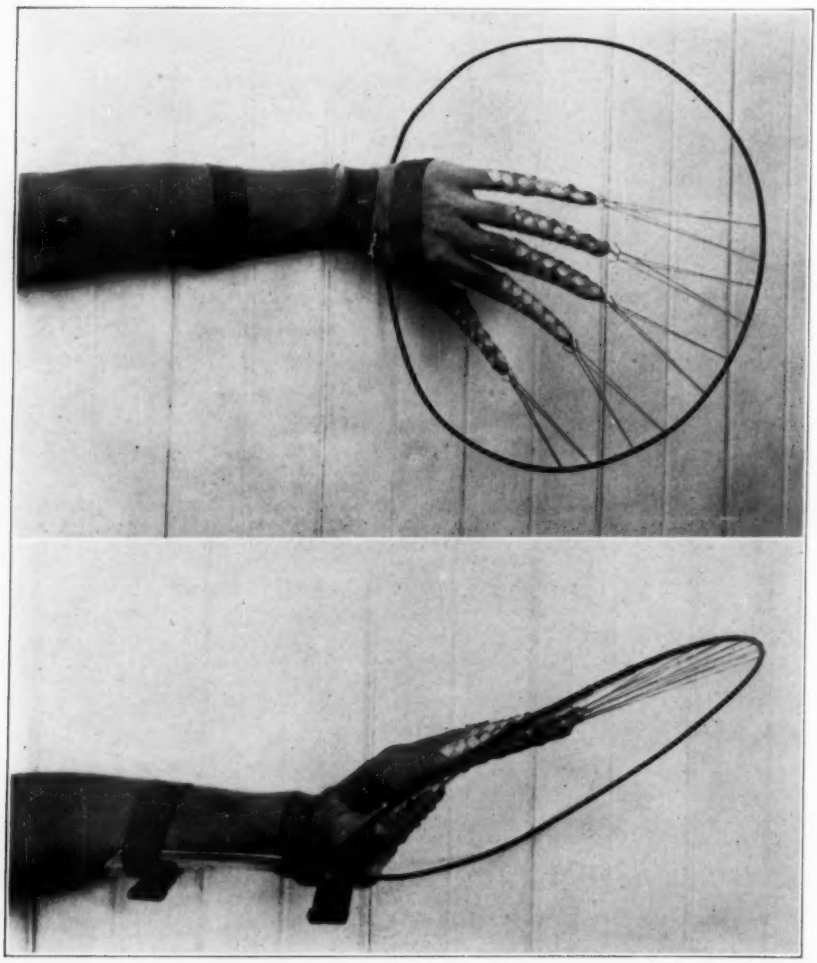


FIG. 1

contracture of the first interphalangeal joint and overstretching of the last phalangeal joint may be anticipated with the development of the well-known "bayonet deformity". This deformity may be prevented by the early application of traction by means of the splint shown in Figure 1.

In association with the hand and finger deformity mentioned above, there is frequently a volar contracture of the radiocarpal articulation. The wrist rarely loses the motion of volar flexion, but often in arthritis dorsal flexion is markedly diminished. Accordingly the splint is made with an adjustable cock-up palmar dome.

The splint is made of light, strong aluminum with enough flexibility so that it will fit any adult arm and function equally well either on the right or on the left hand. It may be bent by firm, steady finger pressure at the portion which lies under the carpal bones. Bending at this point will fit it smoothly and give the desired degree of "cock-up" to the palmar dome. With progressive correction of the volar contracture at the wrist, the degree of cock-up may be increased, and the splint is made strongly enough to enable it to maintain its contour after each adjustment.

In applying the apparatus, finger stalls are slipped over the fingers and attached to the wire loop by simple, small, rubber bands. These bands may be applied in any number, and any degree of traction may be obtained. The finger stall employed is actually designed as a plaything, being meant to grip the finger more tightly the harder the pull is made to remove it.

For the first few days of traction, the finger is pulled in the line of deformity, with the purpose of relaxing the capsular ligaments. The rubber bands are then slowly moved toward the radial side of the spring-wire arch of the splint until overcorrection is attained. The thumb may be treated similarly.

From the standpoint of simple mechanics, the splint pictured has been developed with every regard to the weak, painful, atrophic hand of the arthritic patient. Its lightness and comparative convenience of application make it a device practical from all standpoints to meet a very highly specialized need in the treatment problems of arthritis.

A TOE SPLINT

BY EDWARD N. REED, M.D., F.A.C.S., SANTA MONICA, CALIFORNIA

The ideal dressing for fracture of the phalanges of the toes should give fixation and, in the case of the first and fifth phalanges, protection from pressure. At the same time the dressing should permit the wearing of a shoe.

These fractures are not serious injuries, since they heal readily and very seldom cause any prolonged disability. However, they are very uncomfortable, unless adequately immobilized and protected from pressure; and dressings which afford protection and fixation are often too bulky to allow wearing a shoe.

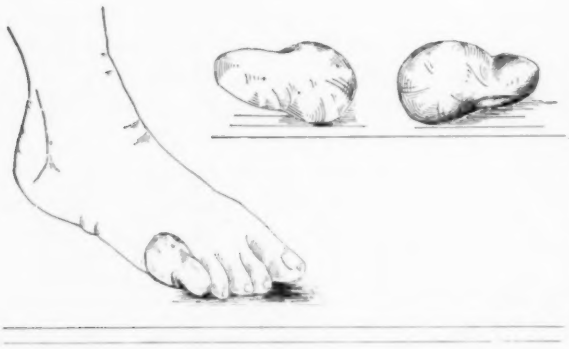


FIG. 1

A dressing which has been found to meet the requirements is composed of a thin metal shell, fitted around the lateral aspect of the digit, extending just beyond the distal end and proximally for an inch or more on the side of the forefoot. The material used has been 22-gage sheet nickle-silver or zinc. A model of the area to be covered by the shell is made by cutting three layers of "hard-coated" plaster bandage to the desired shape, and wetting and molding them over the area to be splinted. When the plaster has set, the mold is carefully loosened, removed, and allowed to dry thoroughly.

The sheet metal is cut to this pattern and then drawn, with a ball-peen hammer on a lead block, so that it fits the mold exactly. This is easily and quickly done with the aid of a very thin-jawed plier, to crimp the metal where necessary to meet creases and folds. The edges of the completed shell should be rolled out slightly with the peening hammer to prevent their cutting into the skin. If desired, such shells can be quickly lined with a layer of moleskin adhesive plaster or chiropodists' thin, adhesive felt, which gives assurance of comfort but adds very little to the thickness. In spite of its thinness, the finished shell is remarkably stiff, because the surfaces curve in two or more planes. It can be applied directly to the skin surface and fixed in position by encircling adhesive strapping. For the first and fifth digits, the application is made to the lateral aspect, in order to protect against lateral pressure, as well as to give fixation. For the others, the shell is made to fit the dorsal

aspect, for the purpose of fixation only. The shoe can then be put on without difficulty and the patient can proceed at once with his usual activities, without pain or discomfort.

With a little experience these shells can be made directly from the metal, without a model, and tried on the digit from time to time as they are hammered out. The whole procedure requires only a short time, and can be completed while the patient waits.

A SIMPLE AND EFFICIENT FINGER SPLINT

BY VERNON L. HART, M.D., MINNEAPOLIS, MINNESOTA

An infected or injured finger frequently requires proper splinting. A simple and light splint, which provides comfort, protection, traction and countertraction, and permits active exercises of the joints, inspection, and roentgenographic studies of the bones, is shown in Figures 1, 2, and 3.

FIG. 1

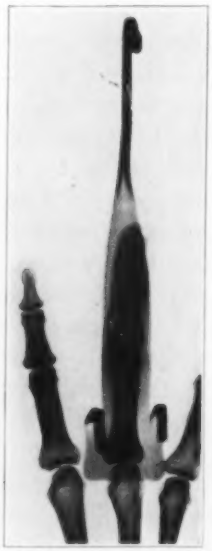


FIG. 2

F.G. 3

The entire splint is made from a piece of sheet aluminum, one-sixteenth of an inch in thickness. Fingernail, skin, or skeletal traction may be used in a line determined by the bend of the splint.

A NEW ELECTRIC MENISCOTOMY KNIFE

BY VINCENT LEGGIADRO, M.D., PORT CHESTER, NEW YORK

Although great strides have been made in our knowledge of the diagnosis and pathology of the internal semilunar cartilage, the surgical treatment has not progressed and the operative technique has shown very little advance in the last decade. With all the attempts made by use of different types of knives, and through different approaches, the difficulty in freeing the posterior quarter of the cartilage has not been overcome. The author has devised a new electric meniscotomy knife, which is simple and practical and has proved eminently satisfactory for the complete removal of the internal semilunar cartilages through the anteromedial approach. By the use of this knife, this operation is performed with a minimum of trauma and little effort, and in far less time than that required by any of the procedures in previous use.

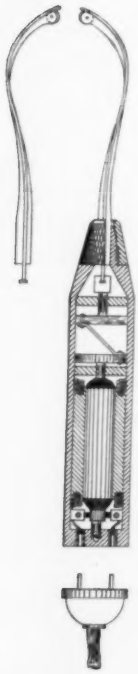


FIG. 1
One-third actual size.

The instrument consists of a very narrow, elongated, S-shaped, stainless-steel armed guide, on the distal end of which is a narrow, rounded blade, completely guarded on its outer aspect and only partially exposed on its concave side. The blade is attached to a narrow, steel, spring rod, which, in turn, is connected to the shaft of a special electric coil or reciprocating shaft of a small electric motor by means of an easily operating lock. This lock permits the quick interchange of knife blades. The blade is tilted about 25 degrees on its axis. It moves forward and backward, with a stroke of two-sixteenths of an inch, having a speed up to about 4,000 strokes per minute. There are two knives —one with a curvature to the right, the other to the left— which are provided with protruding guards on the top. The knife with the distal curvature directed to the right is for the removal of the external cartilage of the right knee or the internal cartilage of the left knee. The other, with the curvature to the left, is for the removal of the opposite cartilages.

The blade guard on its outer aspect is purposely devised to steady the tissue to be severed. The coil or motor is completely enclosed in a steel housing, which is especially constructed to permit sterilization. The vibrations produced by the coil or by the motor are negligible. The instrument is universal and may be used either with an alternating or with a direct current. The frequency and strength of the stroke can be regulated at will by means of a rheostat and rectifier. The instrument is further controlled by a foot switch.

SPLINT FOR CORRECTION OF FINGER CONTRACTURE

BY EDGAR D. OPPENHEIMER, M.D., NEW YORK, N. Y.

Of the various splints used for finger contractures few are practical. The attempt to correct the flexion in the two distal digital joints is usually nullified by the hyperextension of the metacarpophalangeal joint. The banjo type of splint, with traction, is difficult for a patient to apply and presents mechanical slips. Of course, where the flexor tendons are adherent, no splint has any effect, for the value of any apparatus depends for its success on the possibility of stretching the tissues and obtaining the correction. The amount of pressure or force that can be used on a digit is small on account of the surface accessible for the pressure. However, the amount of force necessary is often not great and much can be accomplished by prolonged and frequent stretching in a way that is not uncomfortable.

The apparatus here described is extremely simple. Its action is not nullified by the hyperextension of the metacarpophalangeal joint or wrist. The splint is readily applied by the patient. It is inexpensive, easily adjusted, and has proved effective in overcoming and preventing the flexion contractures of fingers, which are so common after injuries, infections, and nerve lesions.

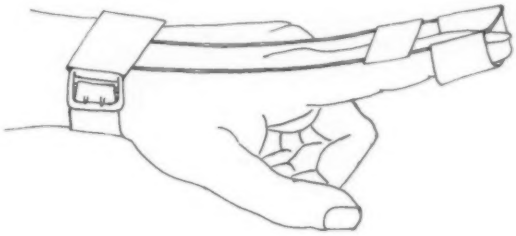


FIG. 1

FIG. 2

The apparatus consists of two parallel spring wires or of one wire bent on itself. Ten to twenty-gage piano wire is used, depending upon the tension desired. At the distal end is a loop or sling of sheet metal, about three-fourths of an inch in width. Made from the ordinary tin can, it is soft-soldered on by an alcohol lamp. Central to it a small platform is similarly soldered, which exerts pressure over the second phalanx, while the distal sling is giving pressure over the pad of the finger. At the level of the wrist a larger piece of metal is soldered on and to this a strap and buckle are attached, which fasten around the wrist. One or more of these finger stretchers can be soldered onto the wrist piece. The piano wire has a natural curve; this is used with the convexity forward and ordinarily makes an arc equivalent to a third of a circle. If the tin is covered with moleskin adhesive, the sharp metal edges can be avoided, the

pressure somewhat softened, and the splint made presentable. The wires can also be covered if the pressure on the dorsum of the hand is uncomfortable. The splint is applied by inserting the finger through the loop and fastening the strap about the wrist.

These splints can be made to suit a particular case in a few minutes without any special tools. They are durable and easily adjustable, and the spring tension can be changed as correction is obtained. When soiled, the moleskin is readily changed. The distal joints are held in extension. The direction of force in the upper part of the wire curve is centrifugal against the hyperextension of the metacarpophalangeal joint. The patient can readily apply this splint in his free time for half-hour periods several times a day; thus, while he is otherwise occupied, the digits can be stretched. The force used should not be great. In cases where stretching is possible, the author has found this splint of great practical value.

News Notes

The Fifth Annual Convention of the **American Academy of Orthopaedic Surgeons** will be held at the Hotel Cleveland, Cleveland, Ohio, on January 10, 11, 12, 13, and 14. A most interesting scientific program has been arranged by the Program Committee, which will include the following:

TUESDAY, JANUARY 12

Morning Session

Injuries to the Accessory Processes of the Vertebrae.
Dr. Merrill C. Mensor, San Francisco, California.

Tendon Transference—Late-Result Study.
Dr. Charles W. Peabody, Detroit, Michigan.

The Cineplastic Amputation.
Dr. Henry H. Kessler, Newark, New Jersey.

Phosphatase. Its Clinical Significance.
Dr. C. Leslie Mitchell, Detroit, Michigan.

The Roentgen Ray in the Assessment of Growth and Health.
Dr. T. Wingate Todd, Cleveland, Ohio.

Executive Session — 12:00 Noon.

Afternoon Session

President's Address.
Dr. Melvin S. Henderson, Rochester, Minnesota.

Torticollis.
Dr. Frederick C. Kidner, Detroit, Michigan.

Symposium on Shoulder Disability—Dr. E. A. Codman, *Chairman:*

Classification of Shoulder Lesions.
Dr. E. A. Codman, Boston, Massachusetts.

Muscle Transplantation for Circumflex-Nerve Paralysis.
Dr. Frank R. Ober, Boston, Massachusetts.

Rupture of the Supraspinatus Tendon.
Dr. Leo Mayer, New York, N. Y.

Symposium on Osteomyelitis—Dr. H. Winnett Orr, *Chairman:*

Factors in the Etiology of Osteomyelitis and Their Relation to Treatment.
Dr. H. Winnett Orr, Lincoln, Nebraska.

The Pathology of Acute and Chronic Bone Infections.
Dr. Dallas B. Phemister, Chicago, Illinois.

The Rôle of the Infectious Organism in Osteomyelitis.
Dr. Ward J. MacNeal, New York, N. Y.

The Rôle of Bacteriophage in Wound-Healing in Osteomyelitis.
Dr. Fred H. Albee, New York, N. Y.

WEDNESDAY, JANUARY 13

Morning Session

Schanz Osteotomy for Fracture of the Neck of the Femur.
Dr. Herman Schumm, Milwaukee, Wisconsin.

Circulatory Studies and Nutrition of Head of Femur.
Dr. W. Eugene Wolcott, Des Moines, Iowa.

The Value of Early Weight-Bearing in the Treatment of Fracture of the Neck of the Femur.
Dr. Samuel Kleinberg, New York, N. Y.

A Reconstruction Operation for Old, Ununited Fracture of the Femoral Neck.
Dr. Paul C. Colonna, New York, N. Y.
A New Technique for Nailing Fractures of the Neck of the Femur.
Dr. José Valls, Buenos Aires, Argentine.

Afternoon Session

Bone Marrow and Its Relation to Orthopaedic Surgery.
Dr. Charles B. Huggins, Chicago, Illinois.
Some Aspects of the Utilization of Sulphur Compounds in Health and Disease.
Dr. Howard B. Lewis, Ann Arbor, Michigan.
Symposium on Fractures of the Ankle—Dr. Philip D. Wilson, *Chairman:*
Etiology and Classification of the Various Types of Fractures.
Dr. Sumner Roberts, Boston, Massachusetts.
Treatment of Severe Fractures of the Ankle.
Dr. Robert D. Schrock, Omaha, Nebraska.
Operative Methods in Treatment of Severe Ankle Fractures.
Dr. William Darrach, New York, N. Y.
Treatment of Malunited and Disabling Ankle-Joint Fractures.
Dr. J. S. Speed, Memphis, Tennessee.

THURSDAY, JANUARY 14

Morning Session

Arthroplasty of the Hip Joint. An End-Result Study of Seventy-Nine Unselected Cases.
Dr. Halford Hallock, New York, N. Y.
The Effect of the Periosteum on the Position of Fracture Fragments.
Dr. Beveridge H. Moore, Chicago, Illinois.
Roentgenographic Diagnosis of Tuberculosis of the Joints.
Dr. Albert B. Ferguson, New York, N. Y.
The Pathology of Hematogenous Osteomyelitis.
Dr. Dallas B. Phemister, Chicago, Illinois.
Dr. C. H. Hatcher, Chicago, Illinois.
Tuberculosis of the Spine in Children.
Dr. Edwin F. Cave, Boston, Massachusetts.

Afternoon Session

Seminar on Low-Back Pain—Dr. Joel E. Goldthwait, *Chairman:*
The Anatomical Structure of the Lumbar Region, Including Variations.
Dr. Theodore A. Willis, Cleveland, Ohio.
The Operative Treatment.
Dr. Edward L. Compere, Chicago, Illinois.
Sacrococcygeal Lesions.
Dr. J. Albert Key, St. Louis, Missouri.
Fasciotomy for Sacro-Iliac Lesions.
Dr. Alan DeForest Smith, New York, N. Y.
The Mechanics of the Lumbosacral and Sacro-Iliac Joints.
Dr. Lloyd T. Brown, Boston, Massachusetts.
Nerve-Root Pain Due to Intraspinal Protrusion of Intervertebral Discs. Diagnosis and Surgical Treatment.
Dr. J. Grafton Love, Rochester, Minnesota.
The Compensation Aspects of Low-Back Conditions.
Dr. Howard L. Prince, Rochester, New York.

Executive Session — 5:30 P.M.

The Annual Banquet will be held in the Ballroom of the Hotel Cleveland on Wednesday evening, January 13, and at that time the Presidential Award will be made, the Scien-

tific Awards will be presented, and the newly elected Fellows will receive their certificates. The speaker at the Banquet will be Prof. T. Wingate Todd.

The local committee have arranged for a large number of carefully selected scientific exhibits and the technical exhibits will also be of interest to the members.

Six radio broadcasts, sponsored by the Academy, have been arranged in connection with the Convention.

The officers of the Academy for the current year are:

President: Dr. Melvin S. Henderson, Rochester, Minnesota.
President-Elect: Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Vice-President: Dr. W. B. Carrell, Dallas, Texas.
Treasurer: Dr. E. B. Mumford, Indianapolis, Indiana.
Secretary: Dr. Philip Lewin, Chicago, Illinois.

Dr. Arthur Krida and Dr. John C. McCauley, Jr., have announced the removal of their offices to 791 Park Avenue, New York, N. Y.

Dr. Charles M. Allaben, 114 Murray Street, Binghamton, New York, announces the association with him of Dr. Alvin R. Carpenter.

The Sixth Walter M. Brickner Lecture at the **Hospital for Joint Diseases** was given on Thursday evening, November 19, by Dr. George R. Minot of Boston. His subject was "Anaemia: Etiology, Diagnosis, and Treatment".

The second 1937 examination of **The American Board of Orthopaedic Surgery** will be held in conjunction with the meeting of the American Medical Association at Atlantic City in June. All applications must be made by May 1 to the Secretary, Dr. Fremont A. Chandler, 6 North Michigan Avenue, Chicago, Illinois.

Effective with the current issue of *The Journal*, the price of foreign postage has been increased to seventy-five cents, making the subscription price to foreign countries $5.75.

At the Eighteenth Annual Meeting of the **Société Française d'Orthopédie,** held in Paris on October 9, 1936, the principal subjects considered were:

1. "Spondylolisthesis", discussed by Dr. Guilleminet of Lyons. Dr. Guilleminet emphasized the importance of the roentgenographic interpretation of these deformities, as well as the pathogenesis and the treatment. He also described the interesting results which have been obtained by surgical treatment either by the double graft or by transverse iliac arthrodesis.

2. "Malunion of the Bones of the Tarsus", presented by Dr. Padovani of Paris. Dr. Padovani discussed the different operative procedures directed toward the correction of these malunions and gave the indications for the operations in the different cases. The object must always be to reestablish the normal relationship between the foot and the leg and to preserve a certain amount of motion in the tibiotarsal articulation.

The First **International Conference on Fever Therapy** will hold its sessions on March 29, 30, and 31, 1937, at the College of Physicians and Surgeons, Columbia University, New York City. The first day will be devoted to the discussion of physiology, pathology, and methods of production of fever. The second day is to be spent in the con-

sideration of miscellaneous diseases treated by fever, such as chorea, rheumatic carditis, ocular diseases, arthritis, leprosy, meningococcus infections, undulant fever, tuberculosis, tumors, skin diseases, etc. The morning of the third day is to be devoted to the consideration of syphilis. In the afternoon of the same day, the treatment of gonorrhoea by fever is to be discussed under the chairmanship of Dr. Stafford L. Warren, Strong Memorial Hospital, University of Rochester, Rochester, New York.

Ministries of Health from many countries have indicated their intention to send official representatives to the Conference. The official language of the Conference is to be English. Baron Henri de Rothschild of Paris is General Chairman of the International Conference on Fever Therapy. Dr. Walter M. Simpson, Dayton, Ohio, is Chairman of the American Committee. The General Secretary is Dr. William Bierman, 471 Park Avenue, New York City.

The Third Congress of the **International Society of Orthopaedic Surgery and Traumatology** was held in Bologna on September 21 to 24 and in Rome on September 25. There was a large attendance and most of the countries of the world were represented.

The name of the Society was changed from The International Society of Orthopaedic Surgery to The International Society of Orthopaedic Surgery and Traumatology.

The meeting was held at the Rizzoli Institute in Bologna and at the Orthopaedic Clinic in University City in Rome. Clinics were given by Prof. Vittorio Putti and his associates on the third and fourth days of the Congress. Seven members from Brazil were elected as well as three members from Chile.

Dr. Hermann Gocht of Berlin was elected President of the next Congress and Dr. Fred H. Albee of New York City was elected Vice-President of the Society. The symposia designated for the next Congress are: (1) The Treatment of Congenital Dislocation of the Hip; and (2) Fracture of the Neck of the Femur. The next Congresses will take place in Berlin in 1939, and in New York City in 1942.

Information has been received about the activities of the **Palestine Society for Crippled Children.** It is non-sectarian and is affiliated with the Society for the Aid of the Crippled in Palestine, Inc., State of New York. Its object is to aid in every possible way the rehabilitating of the crippled child and adolescent in Palestine and to make them self-supporting. There is a large consulting staff and advisory council composed of prominent officials. In addition to facilities for hospitalization, there is an Out-Patient Department in which, during the first six months of this past year, 933 free treatments were given. There is a Department of Social Service and of Occupational Therapy. Some of the workers are volunteers. An industrial school is maintained by the Society and in this the patient is taught a trade which will make him self-supporting. The Society, working with the Government, attempts to obtain statistics of the number of cripples in Palestine and to devise ways and means of preventing the advent of deformities in children, as well as to establish principles for rehabilitation.

The Congress of the **Czechoslovakian Orthopaedic Society** was held in Bratislava on June 27 to 30. It was opened by the President, Prof. Mikula, with clinical demonstrations. At the beginning of the scientific session, the President gave a report on his treatment of various diseases of the joints, in which he considered both operative and conservative methods. For acute joint conditions, he recommended opening and irrigation for forty-five minutes, followed by closure and immobilization of the joint.

The subject of gonorrhoeal arthritis, particularly in the knee, was considered by Dr. Manzoni of Zagreb. Docent Dr. Treger of Bratislava spoke on the importance of serological reactions in gonorrhoeal arthritis, and Primarius Dr. Račanský of Zlin discussed the diagnosis and therapy. Primarius Dr. Minář of Ljubljana reported a case of gonor-

rhoeal osteochondritis of the humerus, and the conservative treatment of gonorrhoeal arthritis by injections of electrargol was discussed by Dr. Hanák.

For treatment of fractures of the femoral neck, Prof. Zahradníček of Prague recommended conservative treatment, or operative treatment only after the conservative treatment had failed. Prof. Frejka of Brno advocated immediate operation wherever possible, to obtain osteosynthesis either by graft or by nail.

The results of experimental work with synovial fluid were reported by Dr. Vavrda of Bratislava.

Assistant Dr. Jeřábek of Prague spoke on the principles and the results of operative treatment of joints, with particular emphasis on the necessity of careful consideration of the indications, especially for plastic operations.

Prof. Frejka gave a general report in regard to diseases of the joints, laying stress on the necessity of distinguishing infections from traumatic or degenerative toxic changes of neoplasm.

Other communications were made by Dr. Havránek, Košumberk; Docent Dr. Burian; Prof. Diviš, Prague; Dr. Pavlík, Brno; Dr. Pavlanský; Dr. Erneyi, Bratislava; Prof. Cmunt, Prague; and Prof. Kimla, Prague.

Prof. Zahradníček was elected President for the two subsequent years. The next Congress is to be held in September 1937 at Belgrade.

The Eighth Annual Meeting of the **American Society for the Study of Arthritis** was held on December 3, 4, and 5 in New York City, with headquarters at the Waldorf-Astoria. Dr. Reginald Burbank of New York City presided.

In the morning of December 3, there was an informal round-table discussion of arthritic problems with particular attention to liver function, gastro-intestinal absorptive phenomena, and allergic manifestations in their relation to arthritis.

The afternoon was devoted to the presentation of papers. Dr. B. H. Huggins of Evanston, Illinois read a paper on "Non-Arthritic Problems in Differential Diagnosis" in which he discussed some of the complicating factors which require special study and adequate roentgenographic examination before the diagnosis can be definitely clarified.

Dr. R. L. Jeffery of Seattle presented a paper entitled "Résumé of Cases Treated with Complement-Fixing Antigens, According to the Burbank-Hadjopoulos Technique". Corollary series of cases were presented with the results of treatment by different methods. Dr. Jeffery stressed the advantage of the complement-fixing antigens as opposed to the socalled pathogen selective.

Dr. Carl R. Comstock of Saratoga Springs reported on the "Regimen for Arthritis as Employed at Saratoga Springs". He emphasized the benefit derived from a careful regimen accompanied by cautiously given baths, manipulation, and massage.

In the evening, the Eighth Annual Open Meeting of the Society was held at the New York Academy of Medicine. Dr. Laurence Mayers of Chicago gave a humorous dissertation on the infinite number of drugs which can be purchased through the druggist by the arthritic patient and stressed the uselessness of most of these preparations.

The second paper, by Dr. Ralph R. Mellon of Pittsburgh, who, for many years, has been working on dissociation phenomena in bacteria, demonstrated how a human hemolytic streptococcus S-type colony was dissociated into a graded series of stabilized variants ending in a non-hemolytic diphtheroid. Dr. Mellon pointed out that mutants could increase in pathogenicity from five thousand to two billion times.

Mr. H. Warren Crowe, Chief of the Charterhouse Rheumatism Clinic, London, gave an address on the "Differential Sedimentation Test in Arthritis", which he considers a more useful diagnostic measure than the blood sedimentation rate. This is a colloidal reaction of the serum proteins and can be successfully used as a control test in the treatment of infection. He feels that the research which resulted in this test is fundamental and that the test itself will be applicable to many fields of medicine, but particularly to arthritis and asthma.

On the morning of December 4, there was again round-table discussion with especial

reference to dissemination of infection from focal areas, menopausal manifestations, and thyroid dyscrasias.

At the afternoon meeting a most interesting demonstration of "Fascial Adhesions" by air injection was given by Dr. Charles Murray Gratz of New York City.

The second paper, by Mr. H. Warren Crowe of London, discussed the rôle of roentgenography in the diagnosis and the control of treatment of arthritis.

Dr. L. G. Hadjopoulos of New York City demonstrated "Direct and Intermediate Pathways for Streptococcic Invasion" with photomicrographs showing human middle-ear and mastoid involvement in which the infective organism did not follow the lines of continuity of infection, but was carried by the blood vessels and lymph channels in a manner confirmatory of the experimental researches in rabbits presented in a previous paper.

On the evening of December 4 a dinner was held in the Jansen Suite for members of the Society and invited guests.

The Eleventh Annual Meeting of the **Deutsche Gesellshaft für Unfallheilkunde, Versicherungs- und Versorgungsmedizin** was held in Hamburg on September 18 and 19, 1936, with Prof. Dr. M. zur Verth presiding.

The first of three chief topics taken up at this convention was "Hereditary Diseases and Insurance", to which the pathologist, Aschoff, contributed the concept of disease affecting biological existence through generations, laid stress on the value of the study of twins, and stated that arteriosclerosis was not inherited. Bauer of Breslau found 272 hereditary conditions of interest to the surgeon, among which he mentioned joint hyperextensibility, cleidocranial dysostosis, osteogenesis imperfecta, and "marble bones".

The second topic was "Meniscus Injury". Ceelen of Bonn gave an account of the non-traumatic degeneration of the semilunar cartilages and Buerkle de la Camp pointed out that a meniscus laceration occurring in an athlete usually heals spontaneously, but that in a miner such an injury rarely heals spontaneously, because the latter's injury usually follows long-continued or repeated trauma of lesser degree.

The third topic dealt with the influence of insurance on the course of disease. Erb of Halberstadt supported the prevailing contention that in accident cases the patients take advantage of their disability compensation to prolong their period of recovery. Gebhardt of Hohenlychen, however, felt that accident cases had been judged too harshly.

Other minor subjects of discussion brought out points of interest. König of Würzburg, in a statistical analysis of over 100,000 fractures, found that pseudarthrosis resulted in 0.48 per cent. of simple fractures and in 5.7 per cent. of compound fractures. Magnus of Munich pointed out the danger of occasional infection in skeletal traction and stated his preference for traction through the tibial tuberosity in fractures of the femur and through a point four fingerbreadths below the olecranon when applied to the elbow. Laarmann of Bochum regarded intracapsular injection of air or uroselectan to be harmless and valuable in the roentgenographic diagnosis of meniscus injuries. In lower-leg amputations, zur Verth emphasized the advantage of covering the stump with a long anterior flap instead of resorting to a long posterior flap, because the latter resulted often in chronic ulceration in the presence of healing by secondary intention. Zur Verth also demonstrated cases of amputation in which wooden prostheses had been of greater value than the leather artificial limb. Stier of Berlin spoke of head injuries which give rise to midbrain symptoms of pyrexia, insomnia, diabetes insipidus, etc. Junghanns of Frankfurt presented a case of localized thrombo-angiitis obliterans of the forearm occurring in a man who had worked for ten years with a compressed-air tool. Graf of Neumünster reported success in the treatment of anthrax with large intravenous doses of serum.

The First Congress of the Austrian Society of Roentgenology and Radiology was held in Vienna, September 4 to 8, 1936, under the chairmanship of Prof. R. Kienböck. There were three principal topics for discussion at this meeting:

1. The use of the x-ray in the study of organic function.

2. The technique of the serialograph: a study of clinical methods.
3. The therapeutic use of the x-ray: the principles of development and the biological considerations in the various methods of irradiation.

The selection of these important topics and the excellent organization of the Congress made it a meeting of international value.

The Congress was opened by the President of Austria, and Prof. L. Freund delivered the opening lecture, in which he considered the development of the use of the x-ray in diagnosis and therapy. He made a special point of the fact that x-ray irradiation was first practised in Vienna.

The three topics were considered at length by a large number of speakers, who discussed first symptomatology and the use of the x-ray in the study of the functions as well as the morphology of the various organs of the body, and showed to what extent efficiency in this use of x-ray has been developed in the last few years.

In connection with the second topic, that of x-ray serialography, the progress afforded in examination of organic function was considered. The advantages and disadvantages of the several serialographic methods were presented, illustrated by different types of films. This demonstration was opened by Dr. Dessauer of Istambul, who presented the development of the method.

The third topic was the methods of irradiation as practised at present. This discussion was opened by Dr. Schwarz of Vienna, who described the principles of development and the biological elements in roentgenotherapeutic irradiation.

The Congress was attended by roentgenologists from different parts of the world. The various addresses showed an appreciation of the use of the x-ray to demonstrate function as well as morphology, and by emphasizing the technical progress they gave an insight into the wider range of vital phenomena made possible by this new technique and indicated that further progress has been made in successfully combating carcinoma.

A memorial to the victims of the x-ray in Austria—Bosch, Czepa, Dautwitz, Dohan, Freud, Haudek, Holzknecht, Pordes, and Schönfeld—was presented at this meeting.

BRITISH ORTHOPAEDIC ASSOCIATION

The Annual Meeting of the British Orthopaedic Association was held in London on October 30 and 31 under the Presidency of Mr. W. R. Bristow. On both mornings at the Royal Society of Medicine, a series of short papers were presented as follows:

Sciatic Scoliosis by Mr. E. N. Wardle, Liverpool

The cases of twenty-six patients suffering from this complaint were reviewed. They fell into two groups,—those without and those with deformity. The majority of patients were in the latter group. Mr. Wardle suggested that diminution in the height of the intervertebral disc between the fifth lumbar and first sacral vertebrae might be of importance in determining the occurrence of pressure on the lumbosacral cord. In all of the patients, complete relief had followed prolonged immobilization of the spine in a plaster jacket applied in suspension.

The Nature and Significance of Protrusio Acetabuli by Mr. John Gilmour, Newcastle

The author contended that protrusio acetabuli commenced in early adolescence, and almost exclusively in the female sex about the time of menstruation. He argued that softening of the Y-shaped cartilage, due to some endocrine disturbance of ossification, resulted in a giving way before the pressure of the femoral head, with consequent increase in depth of the socket. He considered the condition analogous to separation of the upper femoral epiphysis in adolescence ("slipped epiphysis").

Arthrodesis of the Hip for Tuberculous Arthritis by Mr. H. J. Seddon, London

The cases of nineteen patients were reported on each of whom an extra-articular arthrodesis had been performed for healed tuberculous arthritis of the hip. At first, a tibial graft had been used, but the author expressed his preference for a broad full-thick-

ness iliac graft. Emphasis was laid on the advantages of operating through a large window in a previously applied plaster-of-Paris spica. Sound bony ankylosis had occurred in the large majority of patients, and the excellent functional results following the procedure were demonstrated by many of the patients in person.

Culture Methods as a Means of Diagnosis in Surgical Tuberculosis by Dr. Joseph Bamforth, London

Dr. Bamforth outlined the manner in which a high percentage of positive cultures could be obtained from fluids containing the tubercle bacilli—*e.g.*, pus, synovial fluid—on special media. The method has the advantages of reliability and the facilitation of early diagnosis, for a statement one way or the other can be supplied in from two to three weeks after incubation.

Skin Defects Limiting Joint Movement by Sir Harold Gillies, London

Sir Harold demonstrated many patients illustrating the advantages of different forms of skin grafts for contractures and skin defects around various joints. The resulting improvement in appearance and in function was striking. Particular interest was aroused by the case of a patient suffering from generalized oedema of both lower extremities, with extensive skin ulceration.

Chronic Backache by Mr. J. S. Batchelor, London

The cases of 116 patients were reviewed and these fell, in almost equal numbers, into two groups,—*mechanical* backache, due to faulty posture, etc., and backache due to *fibrositis* (acute or chronic, superficial or deep). Emphasis was laid on the frequency with which backache caused by mechanical strain is complicated by the occurrence of secondary fibrositis. Different regimens of treatment were advocated for each of the two groups. For the *mechanical strain* repeated manipulation without anaesthesia, followed by appropriate exercises, had proved more successful than routine manipulation under anaesthesia. *Acute* and subacute fibrositis demanded adequate rest and heat in the early stages, followed by graduated exercise and occasionally by a manipulation under anaesthesia to restore mobility. A manipulation under anaesthesia was usually necessary as a preliminary in the treatment of *chronic* fibrositis. Relief of symptoms had been achieved in almost all of the patients suffering from mechanical strains and in about two-thirds of those suffering from fibrositis.

Oedema of the Feet and Ankles Not Associated with Organic Disease by Dr. A. A. Osman, London

Dr. Osman regarded this condition as a local manifestation of a generalized metabolic disturbance clinically associated with general debility. In all of his patients he had found a lowering of the alkali reserves (acidosis). Hence he believed that the oedema was due to gravity acting in the presence of a water-logged "soil". The majority of his patients had been cured by appropriate periods of rest and by the administration of large doses of alkalis, usually in the form of potassium citrate (up to 1000 grains daily).

A Method of Insertion of the Smith-Petersen Pin by Mr. H. A. Brittain, Norwich

A consecutive series of twenty medial fractures of the neck of the femur were reviewed. They had all been treated by internal fixation after reduction with a Smith-Petersen nail, introduced over a calibrated central guide through a half-inch incision under roentgenographic control. It was claimed that the three main difficulties—the reduction of the fracture, the placing of the nail correctly both in the anteroposterior and in the lateral planes, and the selection of a nail of correct length—were more easily overcome by this method than by an open procedure. Mr. Brittain suggested that it was wise to place the nail near the inferior and posterior margins of the femoral neck, since this minimized the danger that the nail might break out of the capital fragment by adduction and external rotation of the limb, the position most frequently adopted by a patient resting in bed. Three deaths occurred,—one from a pulmonary embolus and two from causes unassociated with the injury. Of the remaining seventeen patients, union of the fragments occurred in all except two.

Principles of Treatment of Fractures by Mr. George Perkins, London

Mr. Perkins emphasized the fact that a fracture is a dual injury,—injury to the bone and injury to the soft parts. He made a strong plea that both should be treated concomitantly by encouraging from the very beginning active movement and use of those joints not immobilized by the necessary splintage.

Results of Treatment of Giant-Cell Tumors of the Long Bones by Mr. Roland Barnes, Manchester

A critical survey of thirty-eight giant-cell tumors, reviewed by the writer at the Memorial Hospital, New York, was presented. The best results in terms of non-recurrence and of joint function had been achieved by curettage and cauterization. Treatment by irradiation alone was not advisable, since it usually meant that histological proof of the nature of the tumor was lacking, that the cartilage of neighboring joints was extensively damaged, and that recurrences were a little more frequent. Complete excision of the tumor was an excellent procedure, though with a very limited field of application. Amputation remained as the treatment of choice in neglected tumors in the upper end of the tibia or in the lower end of the femur.

On the afternoon of October 30, at St. Thomas' Hospital, Mr. C. Max Page and Mr. George Perkins gave a demonstration of operations and showed a large number of patients illustrating end results. In the evening the Association Dinner was held at the Langham Hotel. Among the guests present were the President of the Royal College of Surgeons and Dr. Ralph Ghormley, Secretary of the American Orthopaedic Association.

At the October meeting of the Executive Committee of the **British Orthopaedic Association,** the following were elected to membership:

Full Member

Mr. A. Gillies, Wellington Hospital, Wellington, New Zealand.

Associate Members

Mr. W. G. Campbell, 316 Blackness Road, Dundee, Scotland.
Mr. J. A. Cholomeley, Royal National Orthopaedic Hospital, Stanmore, Middlesex.
Mr. F. S. Cooksey, 20 Oxford Terrace, Hyde Park, London, W. 2.
Mr. G. J. Lillie, Princess Elizabeth Orthopaedic Hospital, Buckerell Bore, Exeter.
Mr. H. F. Moseley, St. Thomas' Hospital, London, S. E. 1.
Mr. A. Quine, Ministry of Health, Whitehall, London.
Mr. D. W. Riley, c/o Dr. S. H. Scougall, B.M.A. Buildings, Macquarie Street, Sydney, Australia.
Mr. R. H. Young, 17 Park Crescent, London, W. 1.

At an earlier meeting of the Executive Committee, the following members were elected:

Full Member

Sir Morton Smart, K.C.V.O., 18 Grosvenor Square, London, W. 1.

Associate Members

Mr. J. S. Batchelor, Guy's Hospital, London, S. E. 1.
Mr. B. Keon Cohen, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.
Mr. W. D. Coltart, 81 Harley Street, London, W. 1.
Mr. D. C. Cranna, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.
Mr. W. Gray, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.
Mr. F. W. Holdsworth, 10 Southbourne Road, Sheffield 10, Yorkshire.
Mr. Geoffrey Hyman, 53 Cowper Street, Leeds.
Mr. A. L. Kenyon, 489 Blackburn Road, Oswaldtwistle, Lancashire.
Mr. G. K. McKee, St. Luke's Hospital, Lowestoft.
Mr. R. G. Pulvertaft, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.

AN ACKNOWLEDGMENT

In the July number of *The Journal* in his article entitled "The Therapeutic Active Principle of Maggots With a Description of Its Clinical Application in 567 Cases", Dr. S. K. Livingston quoted from a paper by Dr. Joseph Buchman published in *Annals of Surgery*, Volume XCIX, page 251, February 1934. This was not designated as a quotation and mention of the article was not given. In making this public apology to its readers and to the journals involved, *The Journal of Bone and Joint Surgery* expresses keen regret for this occurrence, and the author of the article is adding his explanation and apology.

Dr. Livingston's letter follows:

Box 162, Hines, Illinois
October 18, 1936

E. G. Brackett, Editor
The Journal of Bone and Joint Surgery
8 The Fenway
Boston, Massachusetts

Dear Sir:

Your letter of October 15 at hand relative to the similarity between an article published by me in July and an article published by Dr. Joseph Buchman entitled "The Rationale of the Treatment of Chronic Osteomyelitis with Special Reference to Maggot Therapy". I have reviewed the article by Dr. Buchman on this date and find his assertions are entirely correct. While I did not compile much of the material used in this paper, still, I of necessity must assume all responsibility for whatever appeared therein.

This paper, among several others, was compiled during the past year by one or more of three clerks, who are partially employed by me for reference work compilation and typing of texts. It is apparent that through an oversight Dr. Buchman's name and reference thereto was omitted.

I realize the grave injustice done Dr. Buchman and The Journal of Bone and Joint Surgery. I realize also that an omission of credit where credit is due is a serious, unlawful, and embarrassing situation. It is a situation, however, which occurred innocently without forethought of neglect toward Dr. Buchman or his work. Were this not the case, I think it must be evident to all of us that full credit would have been given, because it is simple and easy to give credit, and difficult to explain situations such as this, to say nothing of the ethics involved, which have been violated.

It is my wish to ask the forgiveness of Dr. Buchman and the forgiveness of The Journal of Bone and Joint Surgery for this omission. It is further my wish to correct publicly this error in a subsequent issue of The Journal.

I have made the above statements in fairness to all of us, and only through an oversight, and an apparently inefficient method of compiling information, could such a mistake have been made. I assure you that my method of editing will be radically changed.

Sincerely yours,

(Signed) *S. K. Livingston.*

Dr. Livingston also omitted reference to an article by Dr. Hyman I. Goldstein ("Maggots and Other Insects in Medicine—III" published in *Medical Review of Reviews*, Volume XXXVII, page 480, September 1931) in which he gave much interesting historical data in regard to the use of maggots, and made a statement in which he predicted or suggested that the trend of this therapy might develop along these lines. It is recognized that credit should have been given to Dr. Goldstein for his early suggestion of the trend of development. His priority of statement is hereby acknowledged, and *The Journal* regrets that this omission should have occurred.

Current Literature

DISABILITY EVALUATION. PRINCIPLES OF TREATMENT OF COMPENSABLE INJURIES. Earl D. McBride, B.S., M.D., F.A.C.S. Philadelphia and London, J. B. Lippincott Co., 1936. $8.00.

It is almost impossible for the human mind to cope with all the factors which must be taken into consideration in estimating disability, and Dr. McBride has courageously tackled a very intricate and intangible problem. He has, however, established a physical yardstick for measuring the actual mechanical factors which enter into the picture. In the first chapter, he has reviewed the compensation laws and called attention to the variations in these laws in different states, and continued the discussion from the standpoint of loss of earning capacity and economic and social needs of disabled workmen or their dependents.

Disability, especially that arising from fractures, is graded under the headings of anatomical results, functional results, and economic results, with further subdivisions into percentages (1 = 25 per cent.; 2 = 50 per cent.; 3 = 75 per cent.; 4 = 100 per cent.) and an actual arithmetical estimation. The chapter on examination of the various parts is brief; attention is called to the many disabilities of each part which may occur, thus refreshing the mind of the examiner on many points which might be overlooked and suggesting methods for the evaluation of such disabilities.

The line drawings are excellent. The illustrations showing workmen in various postures necessitated by their trade add to the clarity of the text and call attention to disability, so far as a particular occupation is concerned, which may occur as a result of quite minor injury to a certain part of the anatomy. The physics of locomotion and the effect of distorted anatomy on locomotion are well discussed and well illustrated.

In the treatment of fractures, McBride has covered the anatomy and part of the treatment to illustrate his own views on such treatment. While one may not always agree in the choice of methods, they are all reasonable and in his hands undoubtedly produce amazingly good results. The chapter on nerve injuries is mostly a review of the anatomy of the nervous system. The treatment of back injuries is one of the most difficult things to put into print, because of the complexities of the subject. Here it is handled intelligently and conservatively.

The book is well indexed and nicely printed, and it will arouse interest in a subject which has been much misunderstood and abused. This establishment of a reasonable working basis for an estimate of disability which occurs as a result of accident is an addition to surgical literature which the reviewer believes will be permanent. The next edition will correct some of the minor errors which have been made. All in all, this is an excellent book on a very difficult subject.

L'OSTÉOSYNTHÈSE AU POINT DE VUE BIOLOGIQUE. INFLUENCE DE LA NATURE DU MÉTAL. ETUDE EXPÉRIMENTALE. (Osteosynthesis. A Biological Study with Reference to the Effect of Metals.) G. Ménégaux et D. Odiette. Paris, Masson et Cie, 1936. 35 francs.

The authors have presented the results of their investigations on a subject which needs definite information, and this book should be of very distinct value to all who are interested in the problem of osteosynthesis. It represents the outcome of two years of laboratory investigation and study and of experimental work on animals.

The object of this study was to determine the toxic action of different metals which are used or which may be used in operations on bones. It is known that certain metals have at times a very distinctly toxic action, but the reason for this and the relative value

of different metals are not thoroughly understood. Experience has shown that, even under the most favorable conditions, fractures which are held by metal in good position often fail to unite, often show late and definite osteoporosis, and even at times recur. In this work the cellular changes accompanying the use of different metals are studied and also the results of the investigation of the problem on living subjects are recorded.

The subject has been studied from the mechanical, surgical, and biological points of view, and is treated under four heads: the general consideration of osteosynthesis; the results of investigations of the action of different types of metals on living tissues, as observed by cellular reactions; the results of experimentation on animals; and, finally, the practical results which have been obtained by this study.

In the first part of the book there is given an interesting history of the gradual development of the use of metals, with a discussion of the opinions of different authors and the comparative value of various metal substances which have been used. This is followed by a statement of the objects of the present study and the methods used by the authors.

Five series of experiments were carried out on cultures of tissues in which was observed the cytotoxic action of different metals and alloys on the fibroblasts and osteoblasts of hens, on human osteoblasts, on cultivated osteoblasts (*en vie ralentie*), and on the repair of loss of substance. The control experiments were carried out on animals in two series. The action of the metals on living bone was studied in three series: in one the metal was placed subperiosteally; in another, within the substance of the bone; and in the third the plates and screws were fixed firmly to the bones. It was found that the results obtained were practically identical.

The authors then give the general results of their experiments in which they demonstrate the toxic effect of certain metals and the relative non-toxicity of others. They divide their report on these metals into three groups: first, those metals which are distinctly toxic; second, those which are less toxic; and, third, those which have been found to be quite non-toxic, including their alloys.

This book gives very definite and practical information which, considering the present state of our knowledge of this subject and the large amount of bone work being done, is indeed timely.

BEHANDLUNG DER VERLETZUNGEN UND EITERUNGEN AN FINGERN UND HAND (The Treatment of Injuries and Infections of the Fingers and Hand). Prof. Dr. M. zur Verth. 2 Aufl. Berlin, Julius Springer, 1936. 9.60 marks.

This book attacks the subject of surgical affections of the fingers and hand directly and fundamentally. In addition to presenting an excellent study of fractures, it deals with tissue-destructive injuries which are incipiently clean and with injuries whose first evidence is that of bacterial infection. The book contains fifty-nine significant illustrations and the form of printing allows much to be contained in its 164 pages.

The topics are presented on a clear anatomical basis, and treatment is determined by the architecture of the hand, by the resistance of tissue to infection, and by the relative importance of various structures for function. The book is devoted to the application of principles. Years of experience with great numbers of accident insurance cases enable the author to establish lines of treatment which are supported by statistical proof. Acknowledgment is made to Kanavel in the discussion of suppuration of tendon sheaths and of palmar spaces and to Föhler in the treatment of fractures.

Great emphasis is laid on the prompt excision of potentially infected or necrotic tissue in an open wound. Injuries and infections heal most rapidly with immobilization. Fingers are best immobilized by a flexible wire splint imbedded in a short forearm cast.

It is hardly fair to such a masterful presentation to cite from it a few examples of definite measures of treatment. The thoroughness with which fractures of the fingers, hand, and wrist are taken up makes comment on any one feature difficult. For those

who justly have high regard for the work of Kanavel on infections of the hand and for the principles of Böhler in the treatment of fractures and other injuries, this book will provide an eminent contribution to surgical literature.

ANATOMY OF THE HUMAN BODY. Henry Gray, F.R.S. Ed. 23. Revised and Re-edited by Warren H. Lewis, B.S., M.D. Philadelphia, Lea & Febiger, 1936. $10.00.

This twenty-third edition is testimony to the continued excellence of this work which was first edited by Henry Gray in 1858. Starting with a volume of 750 pages and 350 illustrations, its growth through twenty-three editions to the present one of 1380 pages with 1216 engravings is evidence of the appreciation of this work by the medical public. That the present editor has retained the general plan of presentation of much of the original text and many of the illustrations is also evidence of the quality of the original work. Many of those who first learned their anatomy from the early editions will welcome with satisfaction these familiar descriptions and the illustrations which compare so favorably with the more recent cuts, in spite of the new and improved methods of reproduction.

Much knowledge has been gained in recent years and has enlarged the original work of the anatomists. Especially is this true as regards the subject of microscopic anatomy. This edition has dealt very generously with the new knowledge, and the insertion of this new material has resulted in an enlargement of the scope as well as the size of the volume.

The editor has given to the readers the present status of information in a clear and definitely organized plan. The comprehensiveness of this book is evidenced by the divisions under which the subject is presented: Embryology, Osteology, Syndesmology, Myology, The Blood-Vascular System, The Arteries, The Veins, The Lymphatic System, Neurology, The Organs of the Senses, The Common Integument, Splanchnology, Surface Anatomy and Surface Markings.

In an anatomy of this sort the illustrations must necessarily form an essential supplement to the text, even if they are not of equal value. This requirement will be found to have been satisfactorily fulfilled in this edition. More color has been added to differentiate the various structures in the illustrations of the regional anatomy, which makes clearer the relationship between the different parts.

The use of B. N. A. nomenclature in English has been retained, except for the adoption of the Langley terminology for the autonomic nervous system, but the other nomenclature is given parenthetically, which avoids difficulty or confusion to those who are more familiar with the older terminology. This edition will add another period to the already long life of Gray's *Anatomy*.

DIE PYOGENE ALLGEMEININFEKTION UND IHRE BEHANDLUNG (Generalized Pyogenic Infection and Its Treatment). Prof. Dr. Erich Lexer. 2 Aufl. (Vorträge aus der praktischen Chirurgie, 1 Heft.) Stuttgart, Ferdinand Enke, 1936. 1.60 marks.

Lexer defines the generalized pyogenic infection as the general effect upon the entire body by localized pyogenic processes, with and without metastases. The metastatic form may be purely bacterial or thrombo-embolic; the form without metastases he defines as a pyogenic infection of the blood of either toxic or bacterial form, although a toxic element is provided also by the latter. The author attempts to circumvent such indefinite terms as "sepsis" and "pyemia".

The second portion of the lecture is concerned with bacterial resorption and spread, local tissue reaction, blood-stream destruction, and reticulo-endothelial phagocytosis and resistance as lines of defense. Schulze's experiments are mentioned to show that favorable points of attack for bacteria are furnished by organs where the capillaries are wide and the blood stream is slowed, but nature provides that these organs are important parts of the reticulo-endothelial system,—liver, spleen, bone marrow, and lymph nodes.

The clinical stages of the spread of an infection to the final picture of shock with circulatory failure are well described, with emphasis on the fact that treatment instituted after shock has set in is of little avail.

The first and most important part of treatment of the general infection is the thorough exposure of its localized sources, even to the extent of amputation of an extremity, with subsequent protection and gentle handling of the wound surfaces. In the treatment of the general infection, occasional surprisingly good results have been obtained from immune serum produced in individuals by an autogenous vaccine.

If bacteriophage is used, it should be tested previously to determine its specific effect *in vitro* upon the isolated and cultured strain of bacterium responsible for the infection.

Another method of attack is the direct stimulation of the reticulo-endothelial defense mechanism, if its resistance has not already been too impaired. Colloidal silver is probably without value. Of foreign proteins, only splenic extract has shown a striking effect in animal experiments. The usefulness of producing a sterile abscess is not yet proved. Repeated blood transfusions of 150 to 200 cubic centimeters may be of help, particularly if they come from an individual recently recovered from the same infection for which the patient is being treated. Radiation of the entire body, especially of the spleen and of the long bones, or short-wave radiation of the spleen is still of questionable value.

Jentzer pursues a course of treatment in which (1) a leukocytic response is secured by the intravenous administration of alcohol extracts of pine needles, camphor and cinnamon, with phenol, thymol, and a resin addition (proprietary preparation in 0.6 c.c. ampules under the name of "Themsalin"), and (2) bactericidal antigens are formed by the subcutaneous injection of a mixture of turpentine-free oils and lipoids.

Circulatory collapse may be combated with camphor, caffein, and adrenalin preparations, but the most important means of stimulation is the intravenous administration of 0.5 to 0.75 of a milligram of strophanthin.

REPORTS ON CHRONIC RHEUMATIC DISEASES. BEING THE ANNUAL REPORT OF THE BRITISH COMMITTEE ON CHRONIC RHEUMATIC DISEASES APPOINTED BY THE ROYAL COLLEGE OF PHYSICIANS. Volumes I and II. Edited by C. W. Buckley, M.D., F.R.C.P. New York, The Macmillan Company, 1936. Vol. I, $4.00; Vol. II, $3.50.

Two Annual Reports have been published by the British Committee on Chronic Rheumatic Diseases, appointed by the Royal College of Physicians. The two volumes embody the results of recent observations and studies of chronic rheumatic diseases by many workers. The literature has been carefully and critically reviewed by experts in these subjects. The chapter on nomenclature is of especial interest and value as it expresses the British thought about classification and is also approved by the American Committee. Allergy, focal infection, pathology, orthopaedic treatment, and biochemical studies are discussed in condensed "critical comments". The volume is a storehouse of valuable information for all students of arthritis. Each discussion is simple and thought-provoking.

The second volume is more specific in its review of the present beliefs regarding "chronic infective arthritis", particularly the rôle played by tuberculosis and by the hemolytic streptococcus in rheumatoid (atrophic) arthritis. Clinical and laboratory research of real value is presented in an available way. Even the psychological aspects are discussed.

As the Committee states, all the subjects related to the study and treatment of chronic rheumatic diseases cannot be included in these two volumes, but they are a beginning and are of real value. The comments of experts are always important, not only for the specialist but for the general practitioner. In these reports is also a wealth of bibliographic material, carefully selected. These volumes are, therefore, a valuable contribution to a difficult subject and well worth reading.

A PREFACE TO NERVOUS DISEASE. Stanley Cobb, A.B., M.D. Baltimore, William Wood & Co., 1936. $2.50.

This small book of some 170 pages should be read by every orthopaedic surgeon and then placed in his library for convenient reference. The diction is delightful: scientific enough to be dignified, simple enough to be understandable by every intelligent medical man. No verbiage is to be found; graphic summaries follow necessarily extensive discussions. The book is full of etiological, diagnostic, and therapeutic information, of explanation, and of original and convincing thought.

Chapter III, on "Motor Integration and Locomotion", will aid orthopaedic surgeons to solve many of their most perplexing problems. The boundaries of neurology and orthopaedic surgery are often contiguous and there should be free interchange of those commodities of knowledge which both specialties either have acquired or may discover.

The line drawings and tables with which the text is interspersed add greatly to the reference value of the book. The author's familiarity with old and new neurological literature and research is evident and the last sentence bespeaks a refreshing enthusiasm for his subject: "There is a great future just ahead in this branch of medicine."

We warmly recommend to all general practitioners and specialists in other fields of medicine and surgery "A Preface to Nervous Disease".

ALLGEMEINE GEGENANZEIGEN BEI NICHT DRINGLICHEN CHIRURGISCHEN EINGRIFFEN (General Contra-Indications in Elective Surgical Operations). Prof. Dr. P. Clairmont und Dr. W. Brunner. (Vorträge aus der praktischen Chirurgie, 10 Heft.) Stuttgart, Ferdinand Enke, 1936. 4.20 marks.

This monograph of sixty-six pages is based on numerous publications dealing with fatal postoperative complications, and the authors warn against elective operation in any case in which the patient's condition is liable to precipitate such a postoperative complication.

Operative trauma expresses itself in five ways: (1) impaired cardiovascular function; (2) deficient pulmonary ventilation during and after operation; (3) increased excretory burden by diminished alkali reserve, by chloride loss, and by increased catabolism of protein, fat, and carbohydrate; (4) leukocytosis and increased plasma viscosity; and (5) the so called postoperative symptom complex or shock of peripheral vascular type.

The chief source of contra-indication is the cardiovascular system. The authors regard the simplest and most reliable test of latent cardiac insufficiency to be a tachycardia of 160 on stair-climbing.

Postoperative complications of the lungs and of the respiratory passages cause 25 per cent. of the deaths following operation. Maintenance of the normal acid-base balance by adequate exchange of oxygen and carbon dioxide represents respiratory sufficiency. Active infection of the lungs or of the upper respiratory passages is definite contra-indication to operation. Chronic bronchitis on the basis of emphysema and of bronchiectasis presents a great risk.

Judgment of liver function is difficult. The most sensitive indication of impaired hepatic function is an abnormally increased urobilinaemia. Although any condition which produces a distinct rise in serum globulin will give a positive Takata-Ara reaction, the authors found it to be positive usually in cirrhosis, but also in fatty infiltration and carcinoma of the liver.

Renal function is measured by the familiar tests,—dilution and concentration, and excretion of indigo carmine and phenolsulphonphthalein. Only severe renal damage increases blood non-protein nitrogen and indican. Increased blood protein, determined by the xanthoproteic test, shows severe renal damage in the presence of increased blood indican; otherwise, it is a sign of hepatic insufficiency.

With respect to the hematopoietic system, if both serum globulin and speed of erythrocyte sedimentation are increased, an elective operation should not be performed without determination of the cause of this increase. Aplastic anaemia, refractive both

to iron and to liver therapy, presents an absolute contra-indication. When the primary indication for operation contributes to the anaemia, the importance of the operation itself is greater. Operation on a leukemic patient is permissible with an erythrocyte count of 4,000,000 and a hemoglobin of 80 per cent. A symptomatic thrombopenia with a platelet count of 20,000 to 30,000 provides a poor risk. Essential thrombopenia demands splenectomy. Affections of the spleen are to be judged by the degree of the associated anaemia.

In conditions of disturbed protein metabolism, care must be exercised when gout or amyloidosis is present. In diabetes, ketonaemia or acidosis, or both, represent serious contra-indication. Each diabetic should be controlled by diet and insulin before operation. In the Zurich Clinic, the blood-sugar curve must be maintained at a constant level with a maximum of 160 milligrams per 100 cubic centimeters with absent glycosuria and acetonuria; the alkali reserve should be as nearly normal as possible.

Under the endocrine dyscrasias, hyperthyroidism presents a frequent danger, particularly as a latent hyperthyroidism may be brought to light by operation. Defective states of heart and peripheral circulation should always raise a suspicion of hyperthyroidism. Tetany with a blood calcium below 9 milligrams per 100 cubic centimeters contra-indicates operation. Of hypophysial disorders, the greatest operative danger lies in hypophysial basophilism (Cushing) and in Simmonds' disease.

With respect to age, one finds the minimum resistance to trauma at birth (although Ombrédanne asserts that up to four days of age the infant is as resistant as the adult!) and the greatest at the age of fifteen.

Susceptibility to infection and to trauma is increased during menstruation.

In connection with coexistent generalized infection, primary and secondary lues should receive three weeks of specific treatment before an operation.

Nervous disorders must be regarded.

Indication within the field of operation itself is also open to debate. Total thyroidectomy for cardiac decompensation and angina pectoris has been too extensively performed. The indications for sympathectomy probably require limitation.

The most important guide to elective as well as to emergency operations is an exact diagnosis, together with the conviction that the operation will relieve or alleviate an affection to a greater extent than medical treatment or radiation therapy.

A Textbook of Surgery. John Homans, M.D. Ed. 4. Springfield, Illinois, and Baltimore, Maryland, Charles C. Thomas, 1936. $8.00.

This book is compiled from lectures and other writings of the following members of the Surgical Department of the Harvard Medical School: Arthur W. Allen, David Cheever, Edward D. Churchill, Harvey Cushing, William P. Graves, Robert B. Greenough, John Homans, Gilbert Horrax, Daniel Fiske Jones, William E. Ladd, George A. Leland, Howard A. Lothrop, Richard H. Miller, Edward H. Nichols, Robert B. Osgood, Charles Allen Porter, Tracy J. Putnam, Lyman G. Richards, Edward P. Richardson, Channing C. Simmons, J. Herbert Waite, Wyman Whittemore, and Philip D. Wilson.

In this fourth edition new chapters on "Amputations" and "Plastic Surgery" have been added to round out a text-book which otherwise adequately covered general surgery.

The make-up of the book is better than was that of the first edition, for the whiter paper used sets off the black line drawings more clearly.

Since this is a text-book for medical students, one would expect it to give a little information on practically every surgical subject, without exhaustive treatises on any one subject. The book does just this and does it well.

Bones: A Study of the Development and Structure of the Vertebrate Skeleton. P. D. F. Murray, M.A., D.S.C. Cambridge, England, University Press; New York, The Macmillan Company; 1936. $2.50.

This monograph presents a study of the development and structure of the vertebrate skeleton based on operative, embryonic experiments chiefly on the chick and on the

rabbit. In the first two chapters the author discusses the development of bone replacement,—first, in the preparation of the cartilaginous model; and, second, in the development of the bony structure for which it provides a scaffold. He finds that cartilage is not developed out of undifferentiated mesenchymal cells but from mesenchymal cells which are predestined for such development. Similarly the ossification of the cartilaginous skeleton follows certain predestined patterns, extensively modified, however, by external conditions of growth and of pressure. Such conditions affect not only the shape of the skull and of such bones as the calcaneum but also the internal architecture of bone.

Chapter III considers in further detail these functional changes in the forms of bones and of joints, and Chapter IV discusses and compares the trajectorial theory of bone architecture with Treipel's theory of harmonic adaptation in which muscular stresses are regarded as more important than the mechanical stresses of weight-bearing.

Chapter V discusses similar problems with relation to the mechanical structure of the cartilage and the arrangement of cartilage cells, and Chapter VI presents the mechanism of bony adaptation.

Like all works of research, this book is necessarily incomplete; but it is extremely well written and illustrated, presents a lucid exposition of difficult embryological and morphological problems, and points out probable fruitful directions which further research upon these problems may advantageously take.

A Health Education Workbook for Teachers, Parents, Nurses, and Social Workers. Kathleen Wilkinson Wootten, M.A. New York, A. S. Barnes & Co., Inc., 1936. $1.50.

Miss Wootten dedicates the book to the 10,000 girls of Georgia State College for Women where she has been Professor of Health and head of the Health and Physical Education Department for the past ten years.

The introduction tells of the purpose of the book, sets forth the practical aims of health education, and gives a list of the various organizations which have supported the modern health education program.

This book incorporates such topics as the necessary training and qualifications of the teacher of health and the parents' share in the health program of the child. The teacher's responsibility for the health of the school child is divided into sections,—mental hygiene, speech defects, sex education, posture, etc.

Remediable defects of school children are considered with reference to symptoms, results, causes, method of examination, and the remedies for these defects.

An outline of study is presented, which includes primary, intermediate, and secondary-school health education, along with activities, objectives, and evaluations.

This book is to be recommended to those who are interested in the health education of children, also to those who include this phase of work in their professions.

Leitfaden der Massage (Guides for Massage). Dr. Max Böhm. 6 Aufl. Stuttgart, Ferdinand Enke, 1936. 3.50 marks.

In this sixth edition of "Leitfaden der Massage", Dr. Böhm has given to the medical profession and to those who are engaged in this special therapy, the results of his further experience in this field. In addition to his other medical and surgical interests, Dr. Böhm has always paid particular attention to this form of treatment, especially in its adaptation to the different conditions to which it could be applied. His discussion of the more important details of the methods of application and of the types to be employed in the different pathological and traumatological conditions will be found very helpful by those who have occasion to use this special method of treatment. It is indeed fortunate that Dr. Böhm was able to give to the medical profession the results of his more mature experience before his untimely death.

MEDICAL CLASSICS. Compiled by Emerson Crosby Kelly, M.D. Vol. I, No. 1, Sept. 1936. Baltimore, The Williams & Wilkins Company.

The object of this publication is to revive interest in the history of medicine and in the medical men who have been the high lights in the past. Its purpose is to recall the contributions which these men have made by republishing those works which have made them famous and which show what they have accomplished for medical advancement.

The first number is devoted to Sir James Paget, with a sketch of his life, a list of his voluminous writings, and the eponyms which have come from his special contributions. The original essay on the disease which bears his name is reproduced without change and with the original illustrations.

Other famous men in the history of medicine are to be considered in forthcoming numbers, and all students of medical history will welcome this new publication.

DER ANGEBORENE KLUMPFUSS (Congenital Club Foot). Dr. Med. Hans Debrunner. (Deutsche Orthopädie. Herausgegeben von Hermann Gocht in Berlin. 10. Band.) Stuttgart, Ferdinand Enke, 1936. 20 marks.

Another monograph on club-foot introduces little that is new, but combines the recent concepts of etiology and pathology with an adequate historical review in one volume of 130 pages. Excellent chapters on anatomy, physiology, and etiology are illustrated by rather primitive line drawings. Eugenic prevention of congenital deformities is suggested; sterilization is mentioned, but is not advocated.

The treatment offered is that of Gocht, the writer's teacher and editor of *Deutsche Orthopädie*, to whom the volume is dedicated. Early treatment is urged. In the late treatment the use of osteoclasts is emphasized, but all of the available procedures are classified and discussed.

Introduced as a text-book, the volume will find more favor as a reference work, particularly for those who are interested in the hereditary and developmental aspects.

The *Journal* wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales. Revista mensual de Medicina, Cirugía y Especialidades (Valencia), III, Núms. 29 and 30, 1936.

Anales de Cirugía (Rosario), II, No. 3, 1936.

Archives Franco-Belges de Chirurgie, XXXV, Nos. 3 and 4, 1936.

Boletines de la Sociedad de Cirugía de Rosario, III, Nos. 4, 5, and 6, 1936.

Bulletin of the National Tuberculosis Association, XXII, Nos. 10–12, 1936.

The Child (Washington, D. C.), I, Nos. 3–5, 1936.

Cirugìa Ortopédica y Traumatología (Madrid), I, Núms. 1 and 2, 1936.

Cleveland Clinic Quarterly, III, No. 4, 1936.

Conférences d'Orthopédie et de Chirurgie Infantile. Barboza Vianna. Rio de Janeiro, Est. Graf. Muniz, 1936.

Nutritive and Therapeutic Values of the Banana. A Digest of Scientific Literature. Boston, The United Fruit Company, 1936.

Radiography and Clinical Photography (Rochester, N. Y.), XII, No. 3, 1936.

University of Chicago, The Medical Schools, Announcements for the Sessions of 1936–1937. Chicago, 1936.

ÜBER TUBERKULÖSE SPONDYLITIS BEI FÄLLEN VON KYPHOSIS DORSALIS JUVENILIS SIVE ADOLESCENTIUM (Spine Tuberculosis in Cases of Kyphosis Dorsalis Juvenilis). Robert Hanson. *Acta Chirurgica Scandinavica*, LXXVIII, 297, 1936.

For nine pages the writer debates his priority over Schmorl in the presentation of certain findings, and the fallacy of Schmorl's theory as to the etiology of juvenile kyphosis. Seven cases are reported in detail in which vertebral tuberculosis was coincident with Scheuermann's disease.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

ZWEI FÄLLE VON EPIPHYSENLÖSUNG DER CRISTA ILIACA (Two Cases of Avulsion of the Epiphysis of the Crest of the Ilium). Gunnar Wiberg. *Acta Chirurgica Scandinavica*, LXXVIII, 329, 1936.

After reviewing the development of the pelvic osseous centers, the writer presents two cases in which a secondary epiphysis of the ilium was torn off by the indirect violence of unusually strenuous muscular effort. With strapping and bed rest the lesions healed enough to allow walking in a month.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

NOTES ON THE GENESIS OF GIANT-CELL TUMOURS. Hilding Bergstrand. *The American Journal of Cancer*, XXVII, 701, Aug. 1936.

The author presents a brief review of the literature dealing with the histogenesis of giant-cell tumors. She concludes that we do not know the genesis of solitary giant-cell tumors, but, on the basis of their similarity to the giant-cell tumors in osteitis fibrosa generalisata, they may well be regarded as due to local bone resorption. Certain observations favor the assumption that the primary cause of the resorption is a disturbed circulation. When the lime salts and collagen fibrils are resorbed the original bone-forming syncytium dedifferentiates, with a tendency to proliferation. The giant cells are not osteoclasts but unmasked bone corpuscles. Later regressive changes take place in the tumor, resulting finally in a bone cyst.

Giant-cell tumors are thus neither inflammatory nor neoplastic growths.

Some photomicrographs are presented in support of the theory.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

THE PUNCH BIOPSY IN THE DIAGNOSIS OF TUBERCULOSIS OF THE KNEE JOINT. Michael Burman, Harry Finkelstein, and Leo Mayer. *American Review of Tuberculosis*, XXXIV, 663, Nov. 1936.

With a punch-biopsy instrument, specimens for biopsy were obtained from suspected joints by inserting the punch through the same puncture wound as that used for arthroscopy. The one undesirable feature is the fact that one is unable to remove the specimen under direct view, although theoretically this should be possible. However, the jaws of the instrument can be guided to a particular region, so that this difficulty is of slight importance.

Where it is impossible to obtain consent for biopsy, culture of saline washings from the joints has been made. Dr. Walter Galland, to whom credit for this method is given, instils saline into the joint, leaves the instilation in for a few minutes, and then removes and uses such washings for culture and guinea-pig inoculation. The results are good.—*Clarence A. Ryan, M.D., C.M., Vancouver, British Columbia.*

DISLOCATION AND ELONGATION OF THE LONG HEAD OF THE BICEPS BRACHII. AN ANALYSIS OF SIX CASES. Edgar Lorrington Gilcreest. *Annals of Surgery*, CIV, 118, July 1936.

When the tendon slips from its groove over the lesser tuberosity the tension of the biceps is lessened and the tendon becomes relaxed, producing the classical bicipital syndrome. The dislocation may be acute, recurrent, or gradual; in the first two types the disability is rapidly disabling. The mechanism of production is brought about by force applied by the arm in external rotation and abduction of 90 degrees or more. The tendon may be palpated outside the groove, or the empty groove may be demonstrated.

In recurrent dislocation one can at times reproduce the dislocation by having the patient hold a five-pound weight in the hand with the arm in overhead extension and external reduction. As the arm is adducted, the examiner feels with his fingers a definite snap at the top of the shoulder and along the belly of the biceps as 110 to 90 degrees of abduction is reached, and the patient experiences a sharp pain in the region of the bicipital groove.

Reduction may frequently be accomplished early by flexion at the elbow to 90 degrees, with the hand in supination; the arm is then abducted to 90 degrees in the coronal plane in internal rotation.

If the patient is seen late, or if there is a recurrence, open operation is recommended, with high severance of the tendon and suture to the coracoid process and to the tendon of the short head.

There is an anatomical consideration, an extensive bibliography, and an appendix. Six cases are analyzed.—*N. T. Kirk, M.D., San Francisco, California.*

SUPPURATIVE ARTHRITIS OF THE SACRO-ILIAC JOINT. Joseph B. L'Episcopo. *Annals of Surgery*, CIV, 289, Aug. 1936.

As in other pyogenic joint infections, a blood-borne infection may involve the sacro-iliac joint primarily or this joint may be involved secondarily from a primary focus in the ilium or sacrum adjacent to the joint.

The patient appears acutely ill with a temperature of from 100 to 104 degrees, a rapid pulse, and leukocytosis with an increase in polymorphonuclear neutrophiles. Pain is present in the buttock, in the hip area or over the sacro-iliac joint, and in the lower right or left abdominal quadrant. There is definite tenderness on pressure and percussion over the sacro-iliac joint. In the early stages, the roentgenogram is negative; after three weeks, definite destruction can be demonstrated.

Pus under pressure in the joint follows the path of least resistance; it quickly breaks through the thin anterior sacro-iliac ligament, burrows under the iliacus muscle, and fills the iliac fossa.

Treatment consists of early drainage through the sacro-iliac joint by resecting a block of the ilium over the joint and that part of the sacrum forming the joint, thus permitting the admission of two fingers into the pelvis. The iliac muscle is lifted from behind. Free pus is usually not found until the pelvic cavity is entered. The wound is packed with vaselin gauze and a plaster-of-Paris spica is applied.

Five cases are reported in detail.—*N. T. Kirk, M.D., San Francisco, California.*

RELIEF OF PAIN BY PERIPHERAL NERVE BLOCK IN ARTERIAL DISEASES OF THE LOWER EXTREMITIES. Beverly C. Smith. *Annals of Surgery*, CIV, 934, Nov. 1936.

Forty-six cases of ulceration and gangrene in the lower extremities, caused by occlusive arterial disease, which were treated by nerve block during a five-year period, are reported. The chief indication for treatment is the relief of pain. In this series an increase in local temperature to a varying degree occurred in cases of thrombo-angiitis. Major amputations were reduced to 48 per cent., the greatest number being necessary in the arteriosclerotic diabetic group.

Nerve block was performed by exposing the nerves in the leg under local anaesthesia, well above open lesions, by injection of alcohol and crushing, division, division and sutures, or by crushing two to six millimeters of the nerve.

The nerve supply to the foot is described in detail as well as the surgical anatomy of each nerve and the operative procedure to accomplish its block.—*N. T. Kirk, M.D., San Francisco, California.*

NERVE INJURY IN FRACTURE OF THE PELVIS. Conrad R. Lam. *Annals of Surgery*, CIV, 945, Nov. 1936.

Six of eighteen patients with fracture of the pelvis, treated at the Henry Ford Hospital during a recent one-year period, presented definite evidence of nerve injury. This experience prompted a study of 100 consecutive cases which showed that a nerve injury was present in 9 per cent. of the cases, as compared to fourteen cases or 0.74 per cent. of 1,889 cases collected from the English and German literature during the past twenty years.

The nerves involved in the nine cases were as follows: the peroneal component of the sciatic nerve, six cases; the lateral cutaneous femoral nerve, three cases (bilateral in one case); the superior gluteal nerve, one case; and the posterior branches of the first three sacral nerves, one case.

The preponderance of sensory over motor disturbance, the tardy appearance of symptoms, and the spontaneous regeneration, suggest that the trauma is in the form of stretch or contusion of the nerves.

Case reports of the nine cases are presented together with a bibliographic table showing the incidence of nerve injury in the reported series of cases.—*N. T. Kirk, M.D., San Francisco, California.*

Über die Fensterung der Gelenkkapsel (Fenestration of the Joint Capsule). Joh. Volkmann. *Archiv für orthopädische und Unfall-Chirurgie*, XXXVI, 509, 1936.

Chronic effusion into joints after trauma, operation, arthritis, etc., has been treated in recent years more and more by the so called window operation. There are three ways to perform this:

1. Small incision at the inner upper section, sharp or blunt dissection of the muscles, opening of the capsule, evacuation of the fluid, excision of a piece of the capsule the size of a quarter, which can be used for microscopic examination, closure by sutures of the fascia, muscles, and skin. This can be done under local anaesthesia.

2. Introduction of a large trocar and punching out of a piece of the capsule. By this procedure the danger of an open joint operation is eliminated.

3. Excision of a piece of the capsule to establish a window and closure of the musculature and skin over it. Mandl does not close entirely the joint capsule, and Klapp and Laewen do not sew the joint capsule at all, only the layers over it.

All three methods have the same purpose,—namely, to establish drainage of the joint effusion into the subdermal tissue. The author collected 151 cases from the literature in which this window operation had been performed,—forty-eight by Method 1, twenty by Method 2, and eighty-three by Method 3. The results were as follows:

Method	*Excellent (Per Cent.)*	*Fair (Per Cent.)*	*Failure (Per Cent.)*
1	70.8	6.3	22.9
2	50.0	30.0	20.0
3	71.0	19.3	9.7

In addition, the author describes seven cases of his own in which Method 1 had been performed after chronic synovitis, osteochondritis dissecans, and internal derangements of the knee joint,—all with recurrent joint effusions. In each case perfect restitution was obtained.—*Joseph Wolf, M.D., Iowa City, Iowa.*

Le cifosi dell' adolescenza (Kyphosis in Adolescence). Andrea Albanese. *Archivio di Ortopedia*, LII, 189, 1936.

After a historical review of the subject with an analysis of the more recent work on pathogenesis of the adolescent kyphosis (Scheuermann, Mau, Schmorl), the clinical and roentgenographic picture of the deformity is presented, based upon the study of 150 cases from the Orthopaedic Clinic in Milan.

Albanese subdivides his material into four groups according to pathology: (1) fibro-elastic; (2) osseous; (3) osteochondral; and (4) spondylo-arthral. All these different forms arise and develop in adolescence and may, therefore, be called juvenile or adolescent kyphosis, but each group is characterized by different pathogenic factors, of which part are well known and part are still obscure. For instance, the fibro-elastic type shows certain constitutional signs with weakness of the musculoligamentous apparatus; the osseous form is usually due to some malacic bone disease often of endocrine nature, especially

combined with pituitary dysfunction; the osteochondral form shows changes of enchondral ossification of the vertebral bodies; the changes of the intervertebral discs described by Schmorl may be concomitant (they are frequently found in normal cases) or they are secondary; the spondylo-arthral type represents a form of juvenile deforming spondylosis of obscure origin.—*Ernst Freund, M.D., Venice, Florida.*

SULLE MALFORMAZIONI CONGENITE DEL PERONE (Congenital Deformities of the Fibula). Rosario Marziani. *Archivio di Ortopedia*, LII, 281, 1936.

This relatively frequent congenital deformity is considered from two angles: (1) *defects in shape*, mainly consisting in a backward displacement of the distal end, resulting in absence of the outer malleolus; and (2) *defects in volume*—there may be general hypoplasia, localized at either the upper or the lower end, or hypoplasia may be absent. Eight cases, illustrating these different forms, are reported. Etiologically, external factors such as amniotic adhesions do not seem to be of importance; the deformity is due rather to a *vitium primae formationis*, sometimes comparable to one of the developmental forms of mutation.—*Ernst Freund, M.D., Venice, Florida.*

CONTRIBUTO AL TRATTAMENTO OPERATORIO DELLA INSUFFICIENZA PARALITICA DEL MEDIO E PICCOLO GLUTEO (Contribution to the Surgical Treatment of Paralysis of the Gluteus Medius and the Gluteus Minimus). Poli Antonio. *Archivio di Ortopedia*, LII, 307, 1936.

The different operative methods to improve abductor insufficiency are discussed. A new method is described which has been tried in three cases, apparently with satisfactory results. The method consists in the transplantation of the tensor fasciae latae and of the upper portion of the gluteus maximus to the greater trochanter, and of the vastus lateralis to the iliotibial band above the greater trochanter. The details of this operative method are accurately described.

Under general anaesthesia, a curved incision is made from the anterior superior to the posterior superior iliac spine and then down and below the greater trochanter. The tensor fasciae latae is freed at its anterior margin and severed at its insertion into the fascia. Then the upper portion of the gluteus maximus is separated from the lower portion along a line from the posterior superior iliac spine to the base of the greater trochanter. Full division of the muscle is safe only in the upper part; in the lower, one has to watch out for the inferior gluteal vessels and, especially, for the nerve. The muscle is cut at its insertion into the fascia lata. The distal ends of both muscles are firmly anchored under a bony periosteal flap of the outer surface of the greater trochanter. The vastus lateralis is used only to reenforce the action of the two transplanted muscles. Its proximal fibers are isolated from the femur down to the width of about three or four fingers and are sutured to the supratrochanteric portion of the iliotibial band, previously cut transversely. The leg is kept in abduction of about 30 degrees and the transplanted muscles are fastened under tension. Immobilization in a hip spica cast is maintained for two months.—*Ernst Freund, M.D., Venice, Florida.*

INTERVENTO CHIRURGICO NELLA PARALISI OSTETRICA (Surgical Intervention in Birth Palsy). Mario Peracino. *Archivio di Ortopedia*, LII, 321, 1936.

The author reports five cases with sequelae of birth palsy of four to nineteen years' duration. In two of the cases the lesions were in the upper arm; in three also the forearm and hand were involved. Operative intervention aims mainly at correction of the internal rotation of the humerus, of the pronation of the forearm, and of the flexion of the wrist. The rotation osteotomy of the humerus above the insertion of the deltoid muscle is the method of choice. The pronation contracture of the forearm is corrected by osteotomy of both bones in the middle third. Flexion of the wrist is overcome by arthrodesis

of the radiocarpal joint with shortening of the tendons of the radial extensors. In one case of severe deformity of nineteen years' duration, the Sever operation was performed.—*Ernst Freund, M.D., Venice, Florida.*

SULLE ROTTURE DEL TENDINE DEL QUADRICIPITE FEMORALE (Rupture of the Quadriceps Tendon). Carlo Schapira. *Archivio di Ortopedia*, LII, 329, 1936.

Four cases of rupture of the quadriceps tendon are reported. The characteristic clinical picture is described. The roentgenogram is of importance to rule out fracture of the patella. Soft pictures may even show the interruption of the tendon. The treatment of choice is surgery. Relatively simple in recent cases, the therapeutic problem becomes considerably more difficult in inveterate cases. The wide diastasis makes a plastic operation necessary. Different muscles have been used (biceps, sartorius, gracilis, etc.) or the free transplant of fascia lata. From an etiological viewpoint, in addition to the trauma, predisposing changes in the surrounding tendon tissue have to be considered as they occur after forty to fifty years of age, as diminution of mechanical resistance and elasticity.—*Ernst Freund, M.D., Venice, Florida.*

CONGENITAL DISC-SHAPED LATERAL MENISCUS WITH SNAPPING KNEE. D. Stewart Middleton. *British Journal of Surgery*, XXIV, 246, Oct. 1936.

Four cases of persistence of embryonic disc-shaped lateral meniscus of the knee joint are reported. In each instance the patient had complained of snapping in the knee joint. The disc-shaped meniscus is more liable to be traumatized than the normal one. In the absence of trauma, the snapping sensation is painless.

The author speculates on the etiology of the snapping noise. He believes that in one type a ridge forms on the upper aspect of the meniscus with a concave facet in front of and behind it. When extension occurs the femur mounts the ridge and suddenly rides over it. In flexion the reverse takes place. In other types the snapping is due to the abnormal mobility of the disc.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

SOME EXAMPLES OF DISEASE OF THE VERTEBRAL COLUMN FOUND IN SKELETONS OF ANCIENT EGYPT. A CONTRIBUTION TO PALAEOPATHOLOGY. L. R. Shore. *British Journal of Surgery*, XXIV, 256, Oct. 1936.

This article is a museum of specimens and descriptions of unusual findings in vertebrae from the Predynastic Epoch. Many specimens of ankylosis of various types are described. It is evident that, even in such early periods, tuberculosis, tumors, infections, and trauma were the chief causes of spinal diseases.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

MULTIPLE ARTHRITIS IN PRESUMABLY TUBERCULOUS SUBJECTS: DIFFICULTIES IN DIAGNOSIS AND TREATMENT. Douglas H. Collins and Charles Cameron. *British Journal of Surgery*, XXIV, 272, Oct. 1936.

This is a very carefully written paper on the subject and part of the author's summary follows:

"The cases of twelve patients suffering from various forms of arthritis have been described. In eleven patients the arthritis was multiple. In eleven patients tuberculosis was suspected, and in eight visceral tuberculosis was proved. The arthritis in nine instances was finally not considered to be tuberculous. Six patients were wrongly diagnosed, in the first place, as tuberculous arthritis, and the detrimental effect of treatment adopted on this diagnosis has been recorded. Three early cases of spondylitis ankylopoietica with unusual symptomatology have been included.

The cases have been utilized to illustrate the difficulties in the early diagnosis of

tuberculous arthritis and to warn against the too ready acceptance of a tuberculous etiology in multiple arthritis occurring in presumably tuberculous subjects.

The facts which add confusion to the diagnosis of such cases, and which have been discussed and exemplified, are the following:

1. The insidious monarticular onset of some cases of multiple non-specific arthritis.
2. The coexistence in the patient of some visceral tuberculous lesion, which may or may not influence the course of a non-tuberculous polyarthritis.
3. The possible occurrence of a single tuberculous joint superimposed upon a non-tuberculous multiple arthritis.
4. The occasional incidence of a true tuberculous arthritis in two or more joints.
5. The comparative infrequency of non-specific arthritis of the hip in patients under middle age, and the tendency to suppose such a condition to be tuberculous.
6. Modification of the course of a non-specific arthritis due to early immobilization.
7. The possibility that there exists an atypical tuberculous form of polyarthritis—tuberculous rheumatism."—*Ernest M. Daland, M.D., Boston, Massachusetts.*

HALLUX VALGUS: A COMPARISON OF THE RESULTS OF TWO OPERATIONS. Eric I. Lloyd. *British Journal of Surgery*, XXIV, 341, Oct. 1936.

Forty operations were done on twenty patients. On one side the head of the first metatarsal was excised. On the other side the metatarsal exostosis and the base of the first phalanx were removed. The cases were reviewed one to three years after the operation and the patients were asked for their criticisms. Eleven patients could see no difference between the two sides; four preferred the side on which the metatarsal head had been removed, while the other five preferred the opposite side.

The author concludes that there is no difference in the results of the two operations. —*Ernest M. Daland, M.D., Boston, Massachusetts.*

SPONDYLOLISTHESIS: WITH A DESCRIPTION OF A NEW METHOD OF OPERATIVE TREATMENT AND NOTES OF TEN CASES. Walter Mercer. *Edinburgh Medical Journal*, XLIII, 545, Sept. 1936.

Mercer believes that in all cases of spondylolisthesis there is a bilateral primary center of ossification in the posterior half of the fifth lumbar vertebra. These usually unite in the region of the isthmus about the eleventh year. Due to trauma or to severe strain, there is a slipping of the epiphysis either with widening of the anteroposterior diameter without separation, or with actual separation at the isthmus,—a prespondylolisthetic state. Mechanical factors, including the shearing action of the upper posterior sacrum on the isthmus, then come into play, tending toward gradual stretching of the soft structures and production of spondylolisthesis. The typical clinical syndrome is described. Points to be noted in the anteroposterior roentgenogram are: (1) a characteristic arc or bow which is the outline of the front of the upper part of the body and transverse process; (2) a bitrochanteric length less than the bicristal length; and (3) an upward tilting of the lamina and spinous process of the fifth lumbar vertebra, which casts an inverted Y-shaped shadow. In the lateral roentgenogram, forward displacement, increase in the anteroposterior diameter of the vertebrae, Ullman's sign of forward displacement, and a gap in continuity of the vertebra should be looked for. Displacement forward is graded by the method of Meyerding.

The author reviews the operative methods and presents a new technique in which the anterior approach is used. The intervertebral disc between the fifth lumbar vertebra and the sacrum is resected together with a small part of the lower fifth lumbar vertebra. A wedge of bone from the iliac crest is inserted in the gap and is transfixed by screws slanting obliquely downward through the fifth lumbar vertebra. Of the ten patients whose cases are reported, two were operated upon by the author's method. One died postoperatively, due to superior mesenteric thrombosis; the second became pain-free and had full function with the exception of a stiff lower lumbar region.—*D. B. Slocum, M.D., Iowa City, Iowa.*

STUDIO SPERIMENTALE DEGLI EFFETTI DELLA IMMOBILIZZAZIONE SU ARTICOLAZIONI NORMALI (Experimental Study of the Effects of Immobilization on Normal Joints). O. Scaglietti and C. Casuccio. *La Chirurgia degli Organi di Movimento*, XXI, 469, 1936.

After a detailed discussion of the exhaustive literature concerning this question, the authors report the results of their experiments. They conclude that after immobilization of the knee joint three stages may be differentiated as follows:

1. Changes in the synovia, consisting in proliferation of the superficial layer, successive desquamation of the endothelium, retraction of the villi, atrophy of the synovia, diminution of the secretion of the synovial fluid, and, finally, sclerosis of the subserous layer.

2. Changes in the cartilage, consisting in loss of the basophile staining, irregularity in the cell growth, diminution in the height of the cells, and, finally, lesions and fissures.

3. Atrophy, loss of calcium of bone.

From the results obtained by their experiments, the authors confirm the statement that the three constituents of the joint—synovia, cartilage, and bone—are affected by immobilization.—*Joseph Wolf, M.D., Iowa City, Iowa.*

LA FALTA DE UNION DE LOS ARCOS VERTEBRALES COMO CAUSA DE LAS RAQUIALGIAS BAJAS (The Separate Neural Arch as a Cause of Low-Back Pain). Arthur Steindler. *Cirurgía Ortopédica y Traumatología*, IV, 81, 1936.

The separate neural arch may be considered as a clinical entity only in so far as it presents a syndrome similar to that seen in true gliding of the vertebra. From a pathogenic standpoint it must be considered as a precursory stage from which a spondylolisthesis may develop, whether intra-uterine, in early infancy, or in later life.

Considering the greater difficulty of detection by the roentgenogram as compared with spondylolisthesis and the occasional unexpected finding of a loose arch at operation, it stands to reason that the condition is considerably more frequent than is generally believed.

Because of the lesser deformity and the comparative youth of the patients, conservative treatment gives a higher percentage of good results than it does in spondylolisthesis.

Refractory cases which resist conservative treatment should be fused by operation under the same principles and with the same technique which applies to operation for spondylolisthesis.—*Alberto Inclán, M.D., Havana, Cuba.*

ARTROPLASTIA DE LA CADERA. CASO CLÍNICO DE EVOLUCIÓN ATÍPICA. (Arthroplasty of the Hip. A Clinical Case with an Atypical Evolution.) Alberto Inclán. *Cirugía Ortopédica y Traumatología*, IV, 109, 1936.

This case is interesting in that the surgical intervention failed and, in spite of it, a notable improvement was obtained, thanks to the extraordinary will power and perseverance of the patient.

The author points out that "static and functional reconstruction surgery of the joints requires, more than any other, the most decided and absolute cooperation of the patient, if it is to achieve its purpose".

"The first contra-indication to arthroplasty is pusillanimity and lack of trust of him who requires it."

The case presented illustrates this. The arthroplasty performed was quite lost by infection of a hematoma, with necrosis, not only of the interposed fascia flaps, but also of the cervical portion of the femur, which had to be removed later on as a sequestrum.

Two years after this second intervention, the patient returned for treatment. He walked with crutches and experienced pain as the femur ascended when he tried to bear weight on the affected leg. An operative reduction of the subluxation of the hip was performed and the hip was immobilized in a plaster spica in about 40 degrees of abduction. When the spica was removed, physiotherapy was instituted. However, the contact of the trochanter with the iliac bone caused pain which made walking impossible.

After an interval of some months the fourth and last intervention was done, consisting in a bifurcation of the trochanter after the method of Albee, which effected extraordinary improvement in the stability and in the function of the reconstructed hip. The patient now exhibits a motility of about 60 degrees for active as well as passive movements.—*Alberto Inclán, M.D., Havana, Cuba.*

KYPHOSIS JUVENILIS (SCHEUERMANNS KRANKHEIT). H. Scheuermann. *Fortschritte auf dem Gebiete der Röntgenstrahlen*, LIII, 1, 1936.

Scheuermann described this disease, also called kyphosis dorsalis adolescentium, fifteen years ago and in this article he gives a report on his experiences to date. Two or three vertebrae are commonly affected; the changes are frequently very marked in the construction and evolution of the limbus vertebralis. This may be entirely absent, it may lie near the anterior angle of the corpus, or it may not reach the anterior border. The shape of the limbus is also often modified. In rare cases the changes in the limbus begin a few years before its development, and a wedge-shaped vertebra results. Its origin may be explained as being due to the pressing of the spongiosa into the cartilaginous portion of the vertebral body. The irregularity of the vertebral contour may be considered as the result of the irregularity of the limbus in conjunction with oedematous nuclear prolapse, as has been described by Schmorl. Prognosis cannot be established in the early stage of the disease; kyphotic fixation may result within six months.—*Joseph Wolf, M.D., Iowa City, Iowa.*

LE TRAITEMENT FONCTIONNEL DES FRACTURES PAR COMPRESSION DE LA COLONNE VERTÉBRALE (The Functional Treatment of Compression Fractures of the Vertebral Column). V. Gorinevskaja and E. Drewing. *Lyon Chirurgical*, XXXIII, 44, 1936.

A study of reported cases reveals that not more than 30 to 40 per cent. of the patients have nerve symptoms depending on compression or oedema of the cord, which spontaneously disappear in a few months. Of the patients with severe destructive fractures, 81 per cent. entirely regained locomotion.

After discussing the usual present-day treatment of redressement and prolonged fixation in plaster-of-Paris and convalescent splints, the authors claim that this treatment retards recovery by hindering callus formation which is favored by the hyperaemia caused by use. A definite reconstruction of the architecture takes place over several months and even early in the treatment there is less danger of disalignment than there is after prolonged splinting.

Magnus and others consider that consolidation in these fractures is much more common than is generally believed, and they feel that bed treatment for six to eight weeks is sufficient and that return to work in from two to four months should be expected.

In addition to eliminating the corset, these authors advocate gentle exercises begun immediately after the accident and carried out daily under supervision while in bed. Under this regimen the roentgenogram does not show rarefaction. The authors extended this method to selected cases of compression fractures complicated by nerve symptoms, allowing the patients to begin to walk in about two to two and one-half months. They were not permitted to sit up until they had been walking from two to three weeks. As soon as they can rise and walk, they are given exercises for the standing position. They leave the hospital without corsets and walk for fifteen to twenty minutes, gradually increasing this period as they can up to from three to four hours.—*Joseph Wolf, M.D., Iowa City, Iowa.*

AN OPERATION FOR THENAR PARALYSIS. N. D. Royle. *The Medical Journal of Australia*, II, 155, 1936.

The serious disability in thenar paralysis is due to loss of function of the opponens pollicis muscle. The short flexor and short abductor are relatively unimportant. In the operation described by the author, one of the flexor tendons of the fingers is transplanted to the thumb. The author uses the bifurcated flexor sublimis tendon of the

ring finger, since that is the least missed. Three incisions are necessary,—one at the wrist, one over the base of the ring finger, and one over the thumb. Part of the tendon is sutured to the attachment of the short flexor with the phalanx in flexion, and the other part is stretched to the attachment of the opponens pollicis with the thumb in opposition. This is done by the living suture method,— that is, the tendon is the suture. After the thumb has been kept for ten days in the position described, reeducation is started. This is simple, for, whenever the patient attempts to flex the ring finger, the thumb is drawn naturally into opposition to that finger.—*Dr. Halbstein, Iowa City, Iowa.*

PEUT-ON TENTER UN TRAITEMENT CHIRURGICAL DE LA MYASTHÉNIE? (Should Surgical Treatment of Myasthenia Be Attempted?) J. A. Lievre. *La Presse Médicale*, XLIV, 991, 1936.

While the ultimate cause of myasthenia is unknown, it is interesting to note that in sixty-seven cases of myasthenia in which complete autopsy was performed, twenty-four had a mediastinal tumor in or near the thymic region; thirty-two showed a persistence of hypertrophy of the thymus; and in only eleven was there complete absence of thymic abnormalities. On the other hand, the thymic tumors which are not associated with myasthenia seem to be of the malignant lymphosarcomatous type. As a consequence of these and other cogitations, the authors come to the conclusion that there probably exists some connection between the benign thymomata and myasthenia. They consequently advise careful roentgenographic examination of the thorax in all cases of myasthenia. Where a tumor is disclosed, surgical removal is advised. Where the roentgenogram discloses no mass, a small tumor may still be present. In such an event, the authors recommend conservative therapy by means of medicines and x-ray. If the condition continues to progress, the ultimate, fatal outlook justifies surgical exploration of the anterior mediastinum for thymectomy.—*Henry Milch, M.D., New York, N. Y.*

LA PARALYSIE DU MUSCLE SOUS-ÉPINEUX (Paralysis of the Infraspinatus Muscle). André-Thomas. *La Presse Médicale*, XLIV, 1283, 1936.

The author reports the case of a young man, twenty-five years of age, in whom a peculiar loss of power of external rotation of the left shoulder appeared, following a strain when chopping down a tree. The patient noted weakness only in passing a heavily loaded plate to the left. It is the author's opinion that the function of the supraspinatus muscle is that of abduction and slight internal rotation, while the function of the infraspinatus is mainly that of external rotation. Since both muscles are innervated through the suprascapular nerve, the opinion is expressed that only the portion of the nerve supply to the infraspinatus was interfered with, since the function of the supraspinatus was maintained. In other words, the interruption to the nerve must have occurred at a point beyond the innervation of the supraspinatus. That this is below this point is proved by the fact that there appeared to be tenderness on direct pressure over the course of the nerve as it coursed around the base of the scapular spine.—*Henry Milch, M.D., New York, N. Y.*

DIFFERENTIAL DIAGNOSIS OF PERIARTICULAR FIBROSITIS AND ARTHRITIS. C. H. Slocumb. *Proceedings of the Staff Meetings of The Mayo Clinic*, XI, 363, 1936.

Fibrositis is the most common form of acute or chronic "rheumatism". Almost everyone suffers once if not oftener with it, at least in its mild, subacute form. Although widely recognized abroad and prevalent everywhere, it has received scant attention in this country.

Although the exact cause is not known, it is believed to be attributable to some unidentified infection or toxin. Trauma or exposure to thermal changes sometimes precipitates or causes attacks. Gonorrhoea, gout, rheumatic fever, and atrophic arthritis often affect extra-articular and periarticular tissues even more readily than intra-articular structures. Only the primary type—*i.e.*, without known etiology—is discussed here.

Anatomically primary fibrositis may be classified as: (1) intramuscular fibrositis (myositis) or "muscular rheumatism"; (2) periarticular (capsular) fibrositis; (3) bursal fibrositis or "bursitis"; (4) tendinous fibrositis which, in the palm, may lead to Dupuy-

tren's contracture; and (5) perineural fibrositis, of which "sciatica" or "brachial neuralgia" are common types.

The pathology is the same in all types and depends upon the severity and duration of the process. There is an inflammatory serofibrinous exudate with proliferating fibroblasts and newly formed blood vessels which may go on to indurated, local, tender, thickened tissue or frank, gross subcutaneous nodules. There is no leukocytic reaction.

Periarticular (capsular) fibrositis is much too commonly diagnosed as arthritis. In early cases the pain may be present only during excessive motion or during the first movements on awakening, and the patient may have to hunt for the soreness. If the disease progresses, pain becomes more constant and tenderness less elusive. Joints feel stiffer, but painful motion may still be readily accomplished. There is generally no swelling or hydrops, but capsular thickening may appear. There is little if any redness or muscle atrophy and the roentgenograms represent a normal condition.

In infectious arthritis there is fibrositis plus synovitis, chondritis, and osteitis. Similar in both diseases are: age incidence, age at onset, sex incidence, bodily types affected, and prodromal symptoms (fatigue, chilliness, nervous exhaustion). Atrophic arthritis tends to be a polyarticular invasion, and articular tenderness is expected. Fibrositis is usually found in one or two large joints or in several small joints, and there is generally little or no tenderness. Joints may feel subjectively better after moderate exercises. The sedimentation rate which is increased in atrophic arthritis is usually unaffected in fibrositis.—*Dr. Halbstein, Iowa City, Iowa.*

LES FRACTURES DES APOPHYSES TRANSVERSES LOMBAIRES (Fractures of the Lumbar Transverse Processes). P. Delcoulx et G. Patoir. *Revue d'Orthopédie,* XXIII 97, 1936.

In this study, 94 per cent. of the cases were in males. Two different types are distinguished,—direct and indirect fractures. The authors remark on the relative fragility of the apophyses; they appear very resistant in the dry bone, but in the fresh cadaver they are easily broken by moderate pressure.

The more important feature of the injury, however, is not the bone lesion, but that of the soft parts. The bone lesion itself cannot account for the pain that characterizes the clinical picture. To explain this, one must take into consideration muscular tears and aponeurotic lesions; also injuries to the nervous and vascular systems, more or less extensive hematomata, etc. The lumbar nerves in particular are in close contact with the neck of the transverse processes. The anatomical course of these fracture injuries is also very different; four eventualities are possible:

1. In the first group, there is normal consolidation and the callus forms in the same manner as in other parts of the skeleton;

2. In the second type, exuberant callus is formed, which explains the compression symptoms, nervous radiation, etc.;

3. In the third group, there is progressive absorption of the detached fragment;

4. In the fourth and most frequent type, the detached fragment rests in place and undergoes little or no modification of structure.

The symptomatology also admits the classification into four categories: (1) the habitual form; (2) the benign group; (3) the masked form; (4) severe fracture with abdominal contracture. The authors cite appropriate cases for each of these groups.

The pathogenesis of this contracture is hard to explain; it resembles that found in retroperitoneal or perirenal hemorrhages.

The later course of all of these fractures is no less varied than that of the clinical forms. Some of them may heal rapidly without any trace, but many leave behind a certain rigidity of the spine. There are also neuralgias localized in the lumbar spine and radiation in the abdominal border of crurogenital character, which are very resistant to treatment and may last months and even years. In the cases of the authors, the permanent partial disability was on the average 52 per cent.

Therapeutic indications are very variable. Treatment includes only two possibilities,—either complete conservatism or surgical removal of the fragment. The conservative method is most frequently employed and was used in all of the author's cases. The patient is put to bed for two weeks and massage and electricity or diathermy are applied. A plaster jacket is useless. Injection of cocaine is often of service. The operative technique is also discussed.—*Arthur Steindler, M.D., Iowa City, Iowa.*

PATELLA PARTITA AND ITS CLINICAL IMPORTANCE. A. Pytel. *Slovanský Sborník Ortopedický*, X, 9, 1935.

Seven cases of patellar anomaly are presented,—four with one body at the upper outer pole; one with separation of the inferior pole; one with separation of the medial pole, the other side having the usual type at the upper outer border; and one of duplex patella. Four cases were bilateral.

All of these anomalies are congenital in origin and are found in from 1.5 to 2 per cent. of roentgenograms of knees. With duplex patella are associated varied skeletal anomalies.

Superimposed trauma usually is the cause of the pain which these patients experience. The knees are inferior in type and are easily injured. As a rule, all improve under physiotherapy.—*W. R. Hamsa, M.D., Iowa City, Iowa.*

X-RAY THERAPY IN ORTHOPAEDICS. Jaromir Stepan. *Slovanský Sborník Ortopedický*, X, 297, 1935.

X-ray radiation over plastic reconstructed joints for ankylosis is used by the author to facilitate the production of fibrous tissue over the bone ends. This is begun at the time motion is first attempted and is administered in one to three series, each series consisting of about four radiations at weekly intervals. Dosage is 150 roentgen units, from a different direction at each treatment, filtered through eighty-seven hundredths of a millimeter of copper and a filter of three-tenths of a millimeter of copper plus one millimeter of aluminum.

Tuberculosis of bones and joints is similarly treated. Peripheral joints, however, are first temporarily deprived of their blood supply by a rubber bandage. In the author's opinion, all stages of the disease are benefited. He believes that roentgen therapy has a definite place in orthopaedic surgery.—*W. R. Hamsa, M.D., Iowa City, Iowa.*

OSSEOUS CYSTS OF THE PEDAL NAVICULAR. Aleksander Manzoni. *Slovanský Sborník Ortopedický*, XI, 1936.

The case reported is that of a twelve-year-old male who complained of pain in the left foot, localized to the midtarsal joints. There was no history of trauma. Physical examination showed pronation of the feet with planus and a prominent scaphoid medially, with tenderness to pressure. Roentgenograms showed a cystic area in the tibial half of the left scaphoid, surrounded by a sharp sclerotic border. Operative findings were a cyst containing serous fluid, and thickened periosteum. The pathological diagnosis was productive circumscribed periostitis with cyst formation. The author believes all similar cysts are on a traumatic basis.—*W. R. Hamsa, M.D., Iowa City, Iowa.*

ACUTE OSTEOMYELITIS. Etiology, Symptoms, Diagnosis and Treatment of Eighty Cases. Joseph I. Mitchell. *Southern Medical Journal*, XXIX, 588, 1936.

This article is based on eighty cases of acute infectious osteomyelitis of hematogenous origin. The incidence, location, predisposing causes, causative organisms, pathology, symptoms, diagnosis, treatment, and results are recorded. The author believes that early diagnosis and early treatment improve the prognosis. The operation is conservative, consisting merely of drainage. However, incision of the periosteum gave as high a death rate as drilling into the bone. Mortality was higher in cases caused by streptococcus hemolyticus (33.3 per cent.) than in those due to staphylococcus aureus (10.3 per cent.). Staphylococcus aureus was present in 65 per cent. of the cases. The persist-

ence of positive blood cultures is a bad prognostic sign. Blood transfusions are a valuable aid in treatment.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

TUBERCULOSIS OF THE SPINE WITH PARAPLEGIA. J. H. Kite. *Southern Medical Journal*, XXIX, 883, Sept. 1936.

The history of this condition is touched upon. Twenty cases with paralysis and ninety-six cases without paralysis from the Scottish Rite Hospital for Crippled Children, Decatur, Georgia, are studied. Carefully prepared tables show the age incidence, location of lesions, number of vertebrae involved, duration of disease before onset of paralysis, treatment, time required for recovery, and the results. A significant finding is that the region most frequently involved in the paralyzed group was from the fifth to the ninth thoracic vertebra, while the region most frequently involved in the non-paralyzed group was from the ninth thoracic to the second lumbar vertebra. "Paralysis is seldom due to bony pressure at the point of angulation, but is due to pressure on the cord from the products of tuberculous inflammation. . . . If the paraplegia occurs shortly after the onset of the tuberculous lesion in the spine, the prognosis is good. If it comes on late, five years or more after onset of the disease, the prognosis is poor." Younger children recover better than the older ones.

Patients receiving adequate treatment early after the onset of paralysis recover better than those who are treated later. Laminectomy in this series did not hasten recovery. The author states that when paralysis has disappeared a spine fusion should be done to cure the tuberculous bone lesions.

This article is a valuable contribution to our knowledge of paraplegia as a result of tuberculosis of the spine.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

DIE ZWECKMÄSSIGE EINLAGE (Suitable Foot Plates). M. zur Verth. *Zentralblatt für Chirurgie*, LXIII, 1117, 1936.

The author classifies foot pain into three different types. At first, especially after exertion, the patient feels a slowly increasing tiredness. The site of this pain is most commonly the calf and the tibialis muscles. After a short time, tension pain occurs in the foot joints, especially at the dorsum near the ankle joint. Sometimes this leads to a voluntary abnormal position of the foot in walking, especially on the outer border of the foot. Often morphological changes occur,—for instance, sinking of the second and third metatarsal heads and tension of the toes in cavus. The third stage consists of pressure pain from weight-bearing on the weight-bearing points. Therefore, a good foot plate must function in such a manner as to cure these three types of pain.

The author claims that in the construction of a good foot plate seven different points must be observed:

1. The plate must provide autostatic reduction. The foot plate has to reduce the foot so that the plumb-line from the hip falls in the supporting surface of the foot, as close to the length axis as possible.

2. The plate must preserve its shape independent of the shoe. Nevertheless elasticity is required.

3. The foot plate must be changeable and adjustable. The plaster model furnishes only a rigid shape of the foot and does not indicate the change of form in gait. Therefore, the foot plate constructed from a plaster model must be adjusted on the living foot.

4. The foot plate must not compress the foot more than is necessary. The function of muscles, tendons, vessels, and nerves must not be impeded.

5. The plate should not require too much room, so that the patient needs to buy shoes which are too large. In most cases an external border is not necessary to prevent the sliding outward.

6. The plate must not be too heavy.

7. The plate should not be too expensive, and it must be durable.—*Joseph Wolf, M.D., Iowa City, Iowa.*